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Variety May Add Spice—

But in the Case of Equipment It Does Not Promote Ease and Speed of Making Repairs

ONE of the things that I admire the readers of INDUSTRIAL ENGINEER for is the whole-hearted manner in which they hunt for every possible means of increasing the value and efficiency of maintenance work, to the end that production will not be interrupted by preventable breakdowns of equipment. They are men after my own heart.

This characteristic was forcibly brought to my attention the other day by the following letter from my good friend J. H. Gallant, who is associated with the Canada Cement Company, Limited, Belleville, Ont., Can.:

In this age of specialization, special machinery and specialists, everybody from the wide-awake and progressive executive down to the man on the job, is beginning to realize more and more the necessity for the standardization of materials and of methods of production as well as maintenance, on which production depends.

The standardization of methods is strictly up to the men directly in charge of production and of maintenance.

The high efficiency attainable through standardized methods of production, whether in the shop, the foundry or any other department of an industrial plant is now so generally recognized that hardly more than passing mention of it is necessary here. The benefits of standardization in maintenance methods are, however, not so generally recognized.

It is often a case of "Let Bill do it," and poor Bill, the repair foreman, does it the best he can. Oftentimes very little thought is given as to whether Bill and his men might not have been able to do the job in some easier way and in a much shorter time if they had had the advantage of having frequently done a similar job on the same kind of machine, so that they could use the same methods, the same tools and the same standard material.

Suppose a clutch breaks down, a motor develops a ground or burns out, the teeth get stripped off a gear, or a compensator or a switch is short-circuited. If the equipment in the plant is standardized, the repairman knows immediately what tools to take with him to the job; he knows what materials to draw from the storeroom; the storekeeper will find the materials more easily and save time.

When he gets to the job the repairman will know just how to go at it so as to do it in the easiest and quickest way. He will not have to go back and forth several times for tools and materials.

Ask any experienced repair foreman and he will tell you that on the small repair jobs, which constitute over 80 per cent of the breakdowns in industrial plants, as much and often more time is spent in getting ready for the job and in going back and forth for tools and materials, than in making the repairs.

The real loss, of course, is not in the time taken to do the job, but in the time the machines are idle.

With several kinds of equipment in use it takes longer to train the repairmen to a high degree of efficiency; they will generally take more tools than necessary, and often the wrong ones, and have to return for more material or for the right kind of material. Time lost is production lost.

Another quite important advantage of standardization of equipment is the smaller investment required to carry the necessary spare and repair materials, in the store space required, and the smaller staff with which it is possible to operate the storeroom.

The foregoing should by no means be taken as a brief for the retention of old and obsolete equipment. New and more efficient equipment is being brought out every day, and any change which will save time and promote efficiency, is a move in the right direction.

In replacing old equipment, we should, however, as much as possible, stick to one kind of machine or device for each job.

Practically every machine which has passed the experimental stage and has come to be used commercially has its good points, and when several machines for doing the same job are on the market it is often difficult to choose between them.

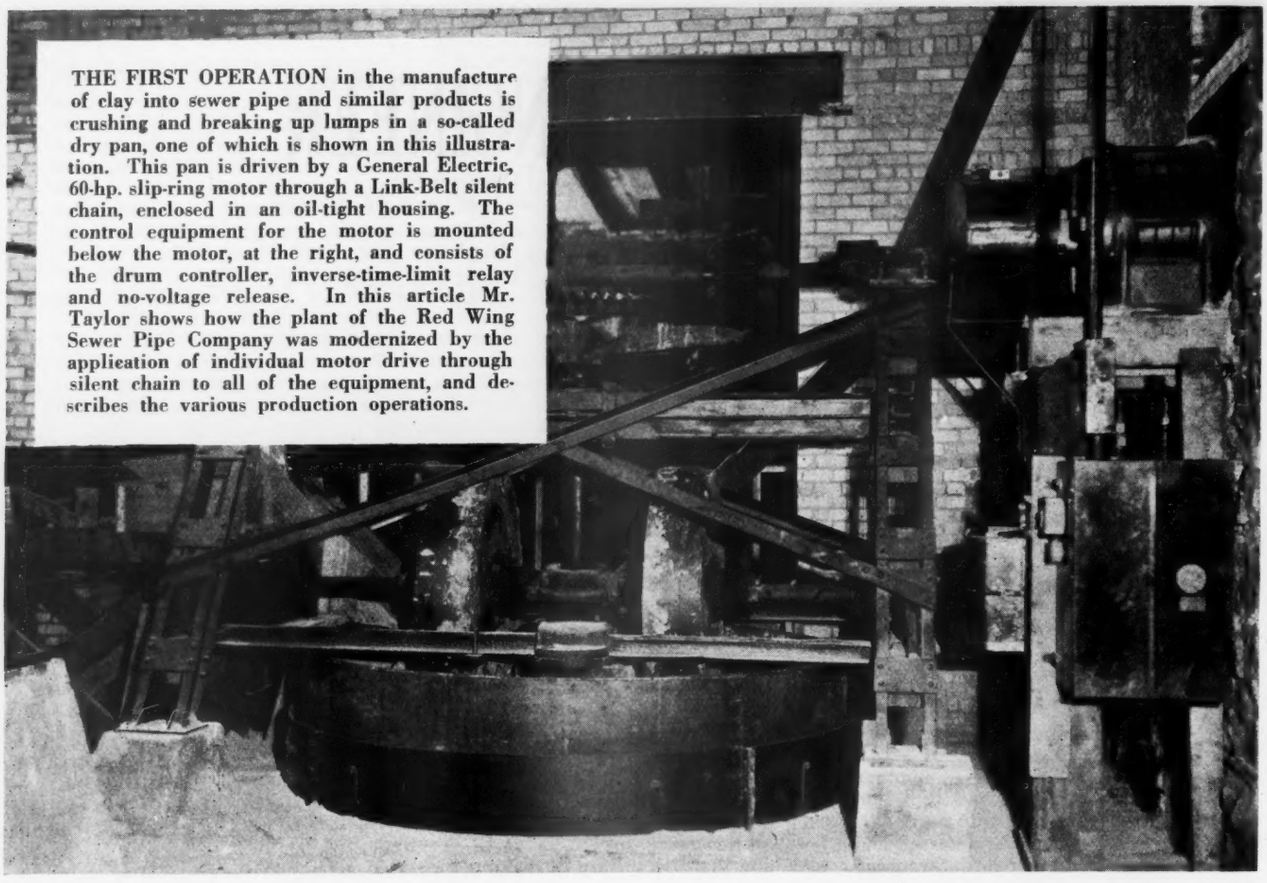
Unfortunately the ideal condition, where it is possible to buy a machine embodying all of the good points of the several machines offered for the same service, is very rarely attained in practice. We cannot get everything in one package.

Nevertheless, after an intelligent selection has been made we should be willing to do without the few good points we have been unable to buy, and make up for them by concentration on the proper maintenance of what we do have.

The time thus saved on maintenance and production will much more than compensate for the few advantages that we may feel we are missing by not having other types of machines.

You may or may not agree with the views with Mr. Gallant has expressed, but I think you will agree with me that he has touched upon a very interesting subject, has presented some good arguments in support of his position, and has given us something to ponder over. In any case, I shall be glad to have you drop me a line and let me know what you think about this matter.

Practical Pete



THE FIRST OPERATION in the manufacture of clay into sewer pipe and similar products is crushing and breaking up lumps in a so-called dry pan, one of which is shown in this illustration. This pan is driven by a General Electric, 60-hp. slip-ring motor through a Link-Belt silent chain, enclosed in an oil-tight housing. The control equipment for the motor is mounted below the motor, at the right, and consists of the drum controller, inverse-time-limit relay and no-voltage release. In this article Mr. Taylor shows how the plant of the Red Wing Sewer Pipe Company was modernized by the application of individual motor drive through silent chain to all of the equipment, and describes the various production operations.

Some Details of Power Drives with

Individual Motors and Silent Chains

That Have Resulted in Greater Economy in the Use of Power and a Reduction in Maintenance Cost and Accident Hazards

By DEAN W. TAYLOR

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WHEN factory A of the Red Wing Sewer Pipe Company, Red Wing, Minn., was destroyed by fire in November, 1922, plans were formulated for rebuilding it and using equipment and methods that would provide the highest all-around operating efficiency. The products of this plant are sewer pipe, flue lining, wall coping, drain tile and similar clay products.

The old plant had been operated by means of a 250-hp. Corliss engine and the various machines had been driven from a system of lineshafts, countershafts, mule drives and bevel gears. While the old plant operators had become used to the original and out-of-date layout and were able by reason of long familiarity with the plant to find their way around in the semi-darkness, a stranger in going through the plant would have been impressed with the great value of an accident policy to anyone inspecting the equipment. Many reasons existed for improving the power application, and not the least of these reasons was safety. Briefly, in common with many other old plants, it contained numerous examples of obsolete methods and equipment.

The first thought of the management was to rebuild and get the plant into production again as quickly as possible. It was the intention to make the new building fireproof, but in the main the plant layout, methods of drive and so on were to be the same as in the old plant. However, at the suggestion of the engineers of the local power company, the officials of the Red Wing Sewer Pipe Company investigated the modernization of the new plant from the standpoint of machinery layout, power drive and power supply, as well as building construction.

Several considerations helped to put such a procedure in a favorable light. In the first place, the generation and use of steam power to drive the machinery in the plant had made the power cost high. Further, due to the fine clay dust which is present in the air, a great deal of trouble was experienced with the use of open bevel or other gears. Besides, these gears were very noisy. The fine dust would work its way into bearings, clog up oil holes, induce rapid wear of bearings and was generally troublesome. In the case of friction clutches, it caused them to drag when open, with consequent rapid wear of certain parts. This necessitated frequent repairs and replacements, making maintenance costs high.

Types of Motors Installed and Machines Driven

Motor Hp.	Type of Motor	Machine Driven
5	Squirrel cage	Dry pan feed belt
60	Slip ring	Dry pan
5	Squirrel cage	Dry pan discharge belt
5	Squirrel cage	First dry clay elevator
10	Squirrel cage	Second dry clay elevator
5	Squirrel cage	Shaker screen
10	Squirrel cage	Wet clay elevators (2)
50	Slip ring	Wet pans (3)
5	Squirrel cage	Press storage belt
2	Squirrel cage	Press feed belt
3	Squirrel cage	Press follower drive
2	Squirrel cage	Press cut-off
10	Variable speed	Waste heat fan
5	Variable speed	Cold air circulating fan
7½	Special	Freight elevators (2)

After a good deal of investigation and discussion, it was finally decided to use individual motor drive on all machines, to drive the machines through silent chains protected by oil-tight housings, and to purchase the electrical energy required.

Considering the conditions in the plant, the use of individual motor drive presented the important advantage that it would permit the most efficient arrangement of production machines by allowing them to be placed in the proper location for handling the raw material, rather than where they would be most convenient for belting to the lineshafting. This was an important consideration, as in the layout of the old plant the location of the lineshafting had determined the location of the machines, oftentimes without more than passing regard for the flow of materials. Another advantage of the use of individual drive was the elimination of mule drives and bevel gears, which at best were not very satisfactory. In addition, the expense and trouble connected with the use of friction clutches were eliminated; injury hazards to workmen were greatly lessened; and the power losses due to friction between bearings and gears were much reduced. Lastly, the noise resulting from the operation of shafting, belting and gears was largely eliminated.

After the decision to use individual motors had been made, the question came up as to the type of drive. All machines to be driven operated at low speed; therefore, direct connection of motors and machines was not possible. In the end, silent chain drive was selected because it was felt that it afforded greater all-around efficiency than would be obtained with belts. Also, a positive drive would be obtained. Another advantage was that the use of chain drive would eliminate long belt drives through floors and walls. Likewise, it would eliminate belt maintenance and reduce the accident hazard incidental to the use of belts and gears, as all chains are enclosed in an oil-tight housing. There was also the advantage that better lighting could be obtained if chain drives were used because these would not interfere so much as do belts and lineshafts. As a result of the elimination of belts and lineshafts, and the possibility of better lighting, the general appearance of the plant would be considerably improved.

The reasons for the adoption of purchased power may be briefly summarized as: Greater economy as com-

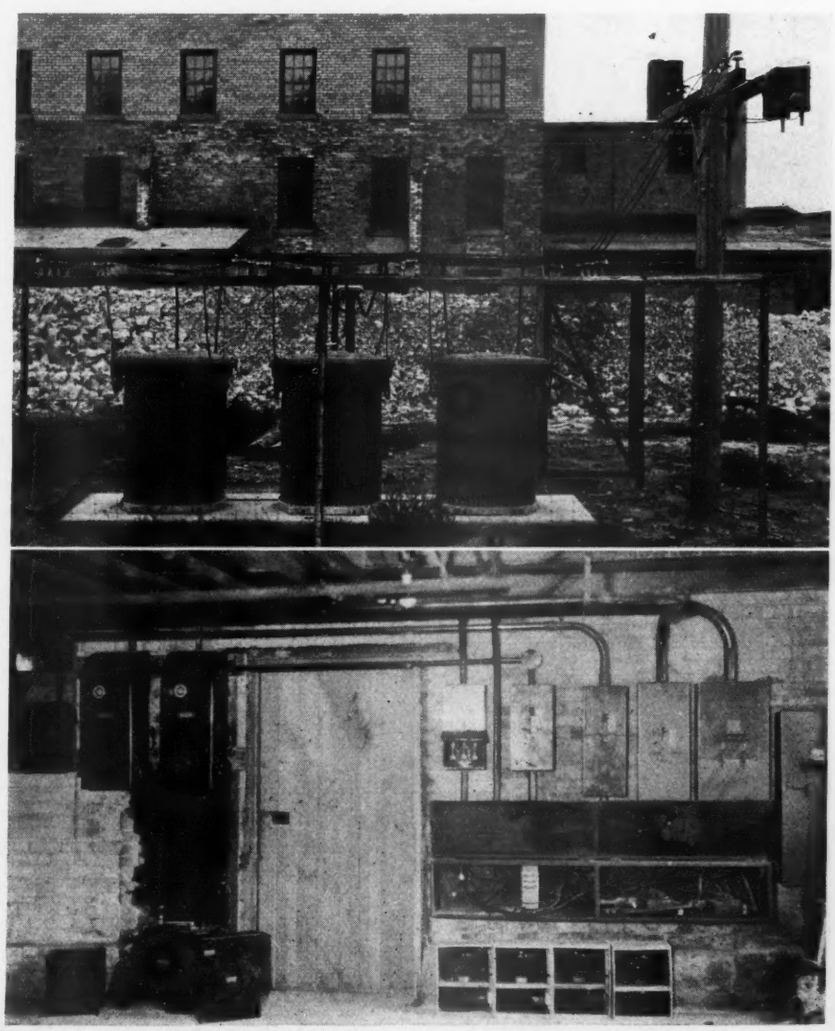
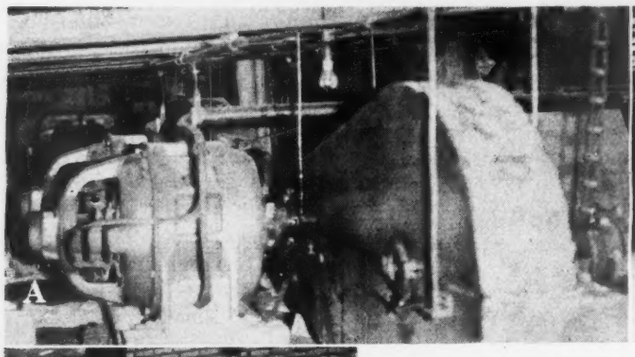


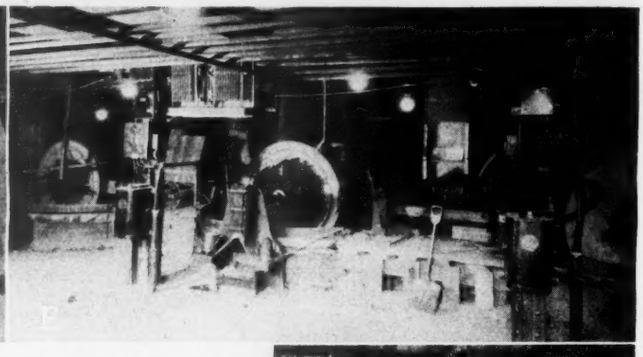
Fig. 1—Transformer substation, above, and service and feeder switches where power circuits enter the plant building.

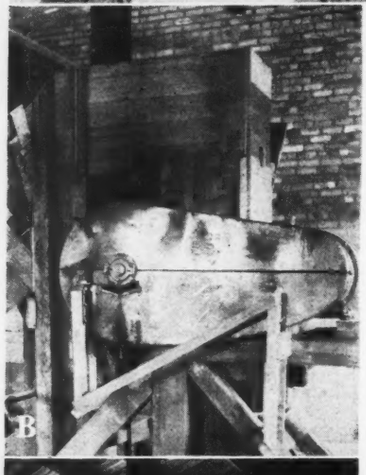
Power for operating the plant is supplied by the Northern States Power Company at 6,600 volts, three phase, 60 cycles, and is stepped down to 440 volts by the transformers shown above. The 440-volt power is brought into the building through underground conduit, the outer end of which can be seen behind the middle transformer. Lighting service is supplied by transformers with 440-volt primaries and 110-220-volt secondaries. The lower illustration shows the service switch at the right and the safety, enclosed-type switches controlling the various circuits in the plant. The meter transformers can be seen in the cabinets just below the switches.

Some Typical Silent Chain Applications

Individual Drives on Equipment in Clay Products Plant







A—These three 50-hp. slip-ring motors drive the wet pans, which are located on the floor above. The wet pans are shown in E.

B—Enclosed silent chain drive for wet clay elevator. The motor is rated at 10 hp. This elevator carries the wet, finely-ground clay from the wet pans to the top floor where it is discharged into a chute leading to the press storage belt which is shown in illustration D.

C—Grog, ground burned ware, is passed through this shaker screen before delivery to the wet pans. The screen is driven by a 5-hp. motor.

D—A 5-hp. squirrel-cage motor drives the press storage belt through an enclosed silent chain. The wet clay is carried by this belt from the chute into which the wet clay elevator discharges it, to the feed belt of the press.

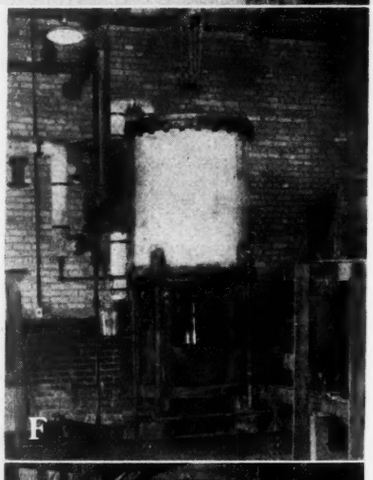
E—These 9-ft. wet pans, in which the clay is ground fine, are driven through silent chains by the 50-hp. motors shown in A.

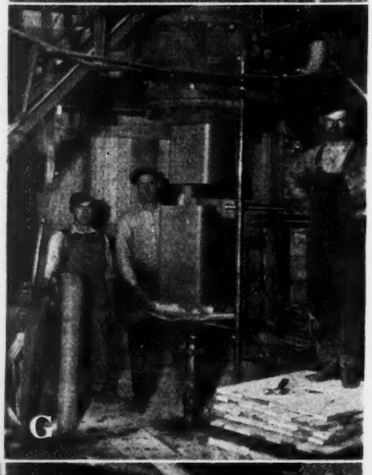
F—Steam cylinder of press which forces the wet clay through dies to form tile and other shapes.

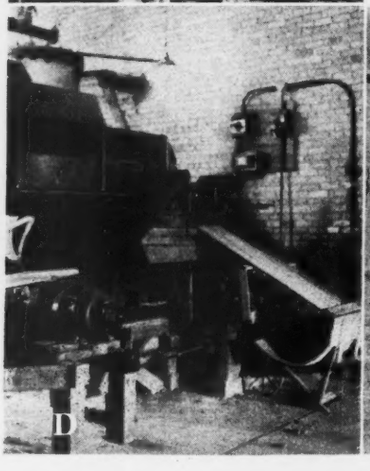
G—This shows the lower end of the steam press. Flue lining was being extruded when this photograph was taken.

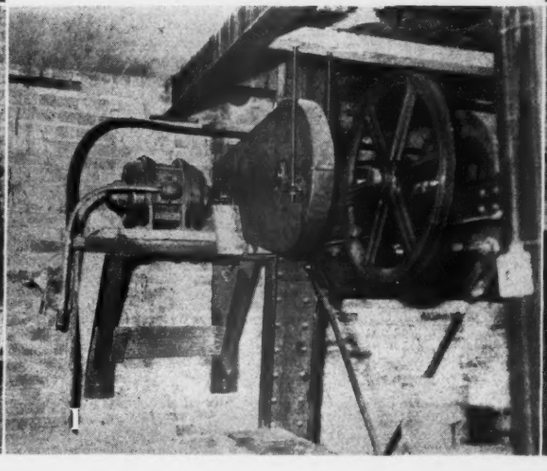
H—One of the two dry clay elevators, which are also driven through silent chains by 5-hp. motors.

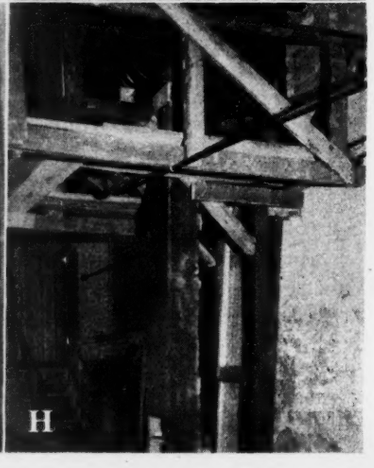
I—Individual 3-hp. motor and chain drive for press former shaft. This shaft carries a die which is forced into the end of the tile as it is extruded, to form the bell end











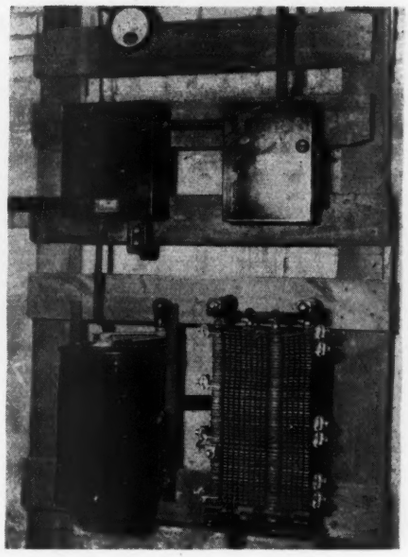


Fig. 2—Typical control panel for slip-ring motor.

The control equipment comprises a line switch, magnetic switch, drum controller, resistor and ammeter.

pared with steam power generated locally; greater flexibility in capacity of power supply; and continuous availability of service for operating fans, lighting service and the like at times when the plant as a whole was not running.

The new plant was put in operation in the early part of October 1923. At present, there are installed 19 General Electric three-phase motors with an aggregate rating of 352 hp. The type of motor used and the machines driven are shown in an accompanying table. A standard motor speed of 900 r.p.m. was selected for every drive, as this speed gave the most economical combination of proper chain speed, bearing load and motor cost. Further, a uniform motor speed makes interchangeability of motors both practicable and convenient. Link-Belt silent chains in oil-tight housings are used on all drives.

All wiring is in conduit and enclosed-type, safety switches are used on the control for each motor. Push-button emergency stop stations are used on all important drives. All motors over 5-hp. rating are protected by inverse-time-limit relays and no-voltage releases. Small motors are protected by thermal overload devices.

With central station service available during every hour of the day and night, it was possible to provide for an adequate lighting installation. The old lighting system, which consisted of an occasional 25-watt lamp, coated with oil and clay and supplemented by portable oil torches, was replaced by an installation of 100-watt, gas-filled lamps in RLM enameled steel reflectors spaced 14 ft., at a mounting height of 9 ft. The connected lighting load is about 32,000 watts.

Electrical energy is delivered by the Northern States Power Company at 6,600 volts, 60 cycles, three phase and is stepped down by the transformer substation shown in Fig. 1 to 440 volts, three phase. Current at 110-220 volts for lighting service is supplied by transformers having 440-volt primaries and 110-220-volt secondaries. The service switch as well as the switches which control the various circuits are shown in the lower illustration of Fig. 1. They are located in the wet pan room where the service wires are brought in to the building, and are very near the load center of the plant.

The service wires from the substation to the plant are 350,000-circ. mil, rubber-covered, single conductors. They are brought into the building through underground conduit, one end of which can be seen behind the middle transformer in the upper illustration in Fig. 1. Underground work was necessary here because of interference by a spur track upon which is operated a yard crane with a long arm covering a comparatively wide area. This crane is used for unloading clay and coal and for stacking sewer pipe and other products after firing. It is driven by a 40-hp. motor and carries 300 ft. of cable which is plugged into receptacles which are located at different points around the entire plant.

The maximum power demand amounts to about 225 kw. and approximately 30,000 kw.-hr. of energy are used monthly.

With this view of the equipment used, it may be interesting to see where and how it is employed in the manufacture of 75 tons of clay products a day. About 100 tons of raw clay are delivered daily to the plant and dumped into outdoor storage. This procedure makes it easier to select and properly blend the clay according to the product to be made. The first operation is rough grinding. The raw clay is dumped from storage onto a feed belt and into what is called a dry pan. This is a large, circular, shallow pan with a coarse-grated bottom, which revolves slowly. Two heavy iron rollers which are free to turn on a fixed shaft serve to break up the lumps of clay as the pan revolves. This pan, which is shown in the illustration at the head of this article, is driven by a 60-hp., slip-ring motor.

As the clay lumps are broken up sufficiently fine to pass through the

Fig. 3—Discharge belt which carries crushed clay from dry pan to elevators.

This belt is driven by a 5-hp., squirrel-cage motor through a silent chain. Note the oil-tight housing which encloses the chain. This housing is partly filled with oil and thus serves the double purpose of protecting the workmen and keeping dust and dirt away from the chain, as well as insuring ample lubrication.

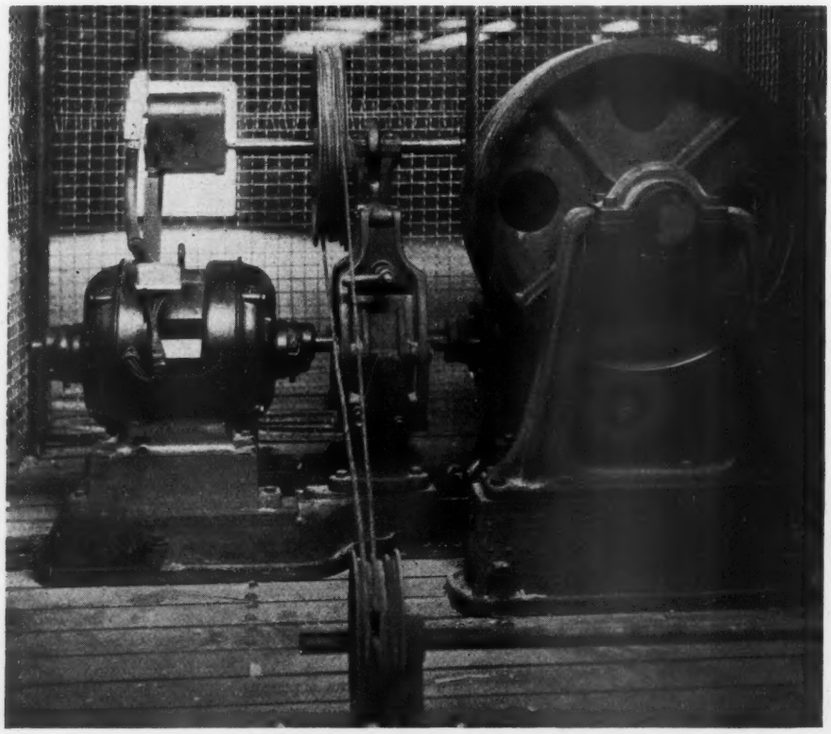
grating of the dry pan, the fine material falls onto a discharge belt which is driven by a 5-hp., squirrel-cage motor. This belt, the drive end of which is shown in Fig. 3, discharges the clay into the boot of an elevator which carries it to the top of the factory building where it is discharged into dry storage. A portion of this elevator is shown in *H* of the illustration on page 216. The clay is held here for a few hours and then is dumped into the hopper leading to one of the wet pans.

These are similar in construction to the dry pans, with the exception that the bottom is solid instead of grated. In these pans the clay is ground fine and mixed with water. About 5 per cent of grog, ground burnt ware, is added to give it the proper consistency. The grog is taken from separate storage and passed through a shaker screen before it is delivered to the wet pans. The shaker screen is driven by a 5-hp. motor and is shown in *C* of the illustration on page 216. The wet pans are driven by 50-hp., slip-ring motors which are located on the floor below. These motors are shown in *A* on page 216. In this case, the speed reduction is from 900 r.p.m., the motor speed, to 175 r.p.m. These wet pans are shown in *E* on page 216. It will be noted in this illustration that the drum controller and protective devices for the motors which drive these pans are mounted on nearby building columns. In addition, several push-button stations for each wet pan are located at convenient points so that in emergency any pan can be stopped at once.

When the charge in one of the wet pans has been properly ground, it is swept out of the pan by a movable arm or baffle and discharged into an elevator and carried to the top floor. Here it is discharged into a chute and then onto a storage belt. An operator transfers the wet clay as required from the storage belt to a feed belt leading to the hopper of the press which extrudes the clay in the form of sewer pipe or other shapes. The storage belt is driven by a 5-hp., squirrel-cage motor through silent chain and is shown in *D* on page 216. The press feed belt is driven by a separate 2-hp., squirrel-cage motor.

The press consists essentially of a steam cylinder, 4 ft. in diameter, which under a steam pressure of 100 lb. per sq. in. forces the wet clay through a die, thus forming the pipe. Views of the upper and lower portions of the press are shown in *F* and *G* on page 216. At the time this photograph was taken, flue lining was being drawn. As the extruded clay leaves the die of the press the forming die supported on the vertical shaft, which is raised and lowered by a separate small motor, is forced into the end of the pipe to form the bell end. Illustration *I* on page 216 shows the 3-hp. motor and chain which drive the press former shaft. The pipe is cut off in standard lengths, placed on small carts and taken by elevators to one of the three drying floors where it is dried by means of the waste steam from the press. This steam is circulated through coils located about 7 ft. above the floor. A temperature of approximately 110 deg. F. is maintained on the drying floors and the moisture given off by the green ware passes off through the monitor-type roof. After the green ware is sufficiently dry, which usually requires from two to eight days for different sizes of pipe, it is burned in a coal-fired, down-draft kiln for 80 hr.

Fig. 4—Winding machine of one of the freight elevators in the dryer. There are two elevators of this type, each driven by a special 7½-hp. motor. These elevators carry the green ware to and from the dryer prior to firing in the kilns.



Maybe You Haven't Noticed It, But—

It has been my experience that the man who is an expert at making excuses is seldom much good for anything else. We all have to admit at times that we have fallen down on the job because we either did not have the ability or the persistency to carry a certain job through to the finish. But when you stop to think of it, these are damaging admissions, as the lawyers say. Lack of brains is a mighty poor argument when raise-day comes around, while lack of persistency somehow always makes me think of yellow.

There aren't many jobs which are absolutely impossible to do; so the chances are that you and I won't get one handed to us very often. Consequently, when I have to explain to myself why I haven't done as directed, I always feel that, instead of saying something which sounds wise and plausible, I ought to say, "Boss, I'm not as good a workman as you think I am. I didn't have brains enough to do that job, nor gameness enough to keep right on trying, nor ambition enough to hustle around and find out how to do it. So I guess you had better give all of the real jobs to somebody else." Then I get right down to business and by that time the job's done. All any man needs to do in a tight place is to be fair with himself and use his mental equipment in doing the job, not thinking of excuses.

Practical Pete

This illustration shows a general view of the Meter Department. The workman in the center is polishing the pivot of an armature shaft, which is mounted in a small lathe. In the background a polyphase meter is being tested and adjusted at the test bench. The shelves above and to the right contain part of the stock of measuring instruments.

Procedure in

Overhauling Electrical Measuring Instruments

With Details of Defects Most Commonly Found, How They Are Remedied, and Methods of Testing After Repairs Have Been Made

By J. D. ZOOK

Superintendent, Gregory Electric Company, Chicago, Ill.

REPAIRING and testing electrical indicating and recording instruments resembles watch or clock repairing much more closely than it does the repairing of motors and other electrical equipment. Most of the parts are so light and delicate that very careful handling is necessary, while the operations and adjustments that are required must be made with an accuracy and precision that are seldom called for in repair work on ordinary types of electrical equipment. In our *Meter Department* we overhaul completely several thousand electrical meters of various kinds a year and a brief account of what the work involves and the methods which we use may be interesting.

Inasmuch as a large part of the work in the *Meter Department* is overhauling watt-hour meters, we will consider these instruments first. In order, however, that the reader may clearly understand some of the operations which will be described it may be well to consider what a watt-hour meter consists of and how it operates.

A direct-current watt-hour meter is essentially a small shunt motor whose armature revolves at a speed that is proportional to the rate at which electrical energy is passing through the meter. A small worm gear is cut into the upper part of the armature shaft so that the latter is geared through a train of small gears to a number of recording dials. These dials thus indicate at all times the total amount of energy that has passed through the meter since it was installed.

In two-wire meters two stationary coils connected in series with each other and with the line supply the field. These are known as the current coils. In three-wire meters the coils are in series with the line. As there is no iron in the fields the field strength is obviously proportional to the current passing through the coils. The armature, which is also called the moving element, or potential element, is vertical and consists of several coils of fine wire, the ends of which are connected to a silver commutator. The coils and commutator are mounted on a long, slender shaft. Two silver-faced brushes make contact on the commutator and supply current to the armature winding, which is termed the potential coil. A resistance and a small shunt coil are connected in series with the armature winding and this entire circuit is, in turn, connected

ELECTRICAL measuring instruments are an indispensable part of the electrical equipment of every industrial plant. They give us all of the many facts which we must know in order to apply and utilize electrical energy efficiently, without undue waste, and with the least danger of injury to the equipment. Such instruments are necessarily of delicate construction and must be carefully handled and periodically checked up and overhauled, if dependable readings are to be obtained. In this article Mr. Zook tells some of the things that happen to measuring instruments in service and describes the methods of repairing and testing that have been developed through years of experience in this work.

in parallel with the line. As the strength of the field flux is proportional to the current flowing in the field or current coils, and the current in the armature coils is proportional to the voltage across the line, the torque of the armature is equal to the product of these two, or the watts.

It is plain that unless some sort of brake or load were imposed on the armature the latter would rotate at a comparatively high speed; also a weak current would cause it to revolve almost or quite as fast as would a stronger current, so that the instrument would be of little or no value. A large aluminum or copper disk is, therefore, mounted on the lower part of the armature shaft and made to rotate between the poles of two strong, permanent magnets, known as drag magnets. The disk does not touch these magnets, but as it rotates between the poles, cutting the lines of force sets up eddy currents in the disk, which oppose its motion and act as a drag. This drag or retarding effect is exactly proportional to the speed.

In order to reduce friction as much as possible, the lower end of the armature shaft is supported on sapphire or diamond jewels. Although two or three different types of jeweled bearings are in use in different makes of meters, as will be explained later, they all accomplish the same ends. Inasmuch as there is no weight on the upper bearing, the latter serving merely to hold the armature vertical and keep it from tipping, this bearing usually takes the form of a fine steel pivot or point which fits into a small hole or recess drilled into the upper end of the armature shaft.

All induction-type, alternating-current watt-hour meters operate on the same general principle, which is much like that of the induction motor, and for the most part differ only in some of the details of construction.

Briefly, the essential elements are two sets of windings, known as the current and potential windings, which are arranged so that a rotating magnetic field is produced which cuts a short-circuited moving member and makes it rotate. The current or series winding consists of two practically non-inductive coils wound with a few turns of comparatively large wire. These coils are wound in opposite directions and are connected in series with the circuit. The current coils are usually mounted on laminated iron cores or poles, which direct the magnetic flux toward the rotor or moving element.

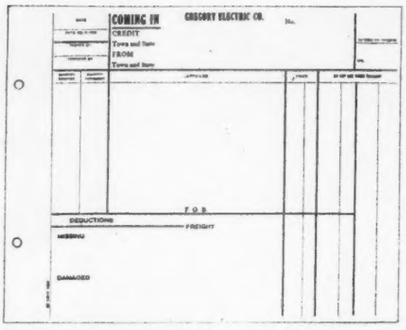

COMING IN GREGORY ELECTRIC CO.
CREDIT
FROM
F. O. B.
DEDUCTIONS
FREIGHT
DAMAGED

Fig. 1—This form is made out upon notification that a shipment of meters is on the way.

The Shipping Department holds this form until the meters come in. After the shipment has been checked for quantity and condition upon arrival the meters are sent, with this form, to the Meter Department.

The potential winding comprises potential and impedance coils which consist of a large number of turns of fine wire and are mounted on laminated iron cores so as to produce a large phase displacement of the field. The potential coils are connected directly across the circuit, either alone or in series with a separate impedance coil.

The rotor or secondary is disk- or cup-shaped and is made of aluminum. It is mounted on a shaft which is supported on jeweled bearings and is so placed that it rotates through the magnetic field produced by the current and potential windings. As before, the rotor also revolves between the poles of two permanent magnets which, by reason of the eddy currents which are set up, tend to stop the rotation and thus serve as a regulating device.

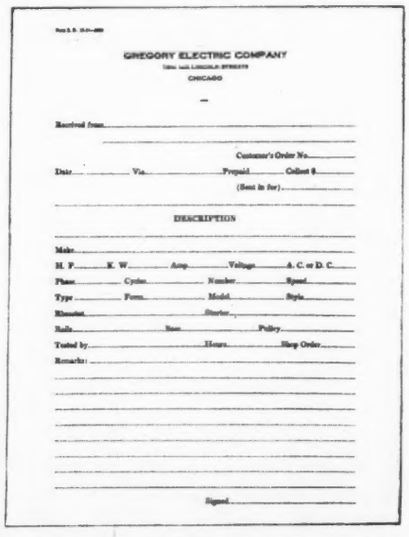

GREGORY ELECTRIC COMPANY
CHICAGO
Received from
Customer's Order No.
Date Via Prepaid Collect $
(Sent in for)
DESCRIPTION
Make
H. P. K. W. Amp. Voltage A. C. or D. C.
Phase Cycles Number Speed
Type Form Model Style
Rheostat Starter
Rails Base Pulley
Tested by Hours Shop Order
Remarks:
Signed

Fig. 2—A record is made on this form of all instruments which are sent in for repairs.

This record form, which is used for all equipment that comes in for repairs, is sent along with the shipment to the proper department, in this case the Meter Department.

Electrical measuring instruments come to our *Meter Department* in three different ways, so to speak. That is, we have purchased them, to be overhauled and sold; they have been offered to us for sale; or they have been sent in for repair by some outside concern. The general routine and order forms for handling equipment from the time it is received in our plant until it is finally disposed of, were described in my article in the August, 1923, issue of INDUSTRIAL ENGINEER, but for the sake of completeness brief mention may be made of it as we go along.

If the meters have been purchased by us, a *Coming In* order is made out on the orange-colored form shown in Fig. 1. This form is sent to the *Shipping Department* and held until the shipment comes in. Upon arrival it is checked for quantity or number of pieces and the instruments are sent, along with the *Coming In* order, to the *Meter Department.*

If the meter or meters have been sent in for repairs one copy of the white form shown in Fig. 2 is made out and sent with the shipment to the *Meter Department.* In any case, a white tag is made out, showing by whom the meters were sent in, and wired to the instruments.

The first step is to make a thorough examination of each meter to determine the nature and extent of the repairs needed. This involves taking it all apart and testing the coils, examining the pivots, jewels and so on with great care. If the meter has been sent in for repairs the customer usually requests that we give him an estimate of the cost of doing the work. In many cases only comparatively minor repairs are needed. Often, however, the meter is in such poor condition that it is not worth repairing; that is, repairs would cost about as much as a new or overhauled meter. In any case, we notify the customer of the results of our examination and put the meter aside until he lets us know what his wishes in the matter are.

Substantially the same procedure is followed in the case of meters which have been purchased, or which have been offered to us for sale. If we find that a meter which we have

purchased is in such condition that the cost of repairs will be excessive, we junk it. If it has been offered to us for sale and we find that we cannot overhaul it at a reasonable cost, we return it to the customer, or make some other mutually satisfactory arrangement.

A good many things can happen to a meter through abuse, accidents or neglect, so that while many of the instruments which come to us are in very fair condition many others have almost everything the matter with them. For example, oftentimes a meter is dropped. This will almost invariably break the jewels or the pivot, or both. In addition, other damage may be done. Or in the case of a watt-hour meter, it may have been allowed to run for 10 or 15 months without oiling or other attention, with the result that the glass-hard pivot cuts into the jewel bearing, to the consequent detriment of both. This condition will make the moving element rotate more slowly, so that it reads low. Usually this condition is discovered only when the meter is checked up or recent readings are compared with those taken previously. Again, a short-circuit or unduly heavy load will burn out the current coils; or lightning will burn out the potential coils, and occasionally wreck the entire mechanism.

Assuming, however, that the meter is not in too bad condition for repairs to be made at a reasonable cost, each part is gone over in turn and the necessary work done on it. Usually the first step is to give the entire meter a thorough cleaning. To this end all of the parts except the coils are cleaned by immersing them in clean benzine. This treatment will remove all of the old oil and dirt. When the coils of a meter have been thoroughly roasted, through an overload or other mishap, the entire mechanism is covered with a dirty, brown deposit which can best be removed by immersing the parts for a short time in a strong, boiling-hot solution of lye. For this operation the gear train is disassembled and the gears strung on wires. Upon removal from the lye the parts are rinsed in clean water and given a quick dip in a mixture of equal parts of nitric and sulphuric acids, full strength. This dip brightens up the metal and is followed by a rinse in cold water and then immersion in hot water, to remove all traces of acid. Inasmuch as the parts are then hot they can easily be dried by shaking them in sawdust for a moment.

If the finish on the cover of the meter is in good condition it is rubbed up and polished. Otherwise the old finish is removed by immersing the cover in the lye solution preparatory to refinishing it. We refinish covers by giving them three coats of Black Railway Rubbing Varnish. Each coat is baked on by keeping it at a temperature of 300 deg. F. for three or four hours.

We are then ready to make such repairs to the meter mechanism as may be necessary. Beginning with the armature or moving element, the pivots are carefully examined under a magnifying glass to determine just what condition they are in. If a pivot is broken or badly worn it is replaced. The lower pivot is screwed into the lower end of the armature shaft, so that replacing it is simply a matter of unscrewing the old pivot and putting a new one in its place.

It may be noted here that the lower pivots are of two general types. One type of pivot resembles those used in clocks and watches and is formed by turning down the end for a distance of about $\frac{1}{16}$ in. to approximately the diameter of an ordinary pin. The bearing used with this type of pivot consists of a sapphire ring- or hole-jewel resting on a cap jewel or endstone. The pivot passes through the ring jewel and rests on the cap jewel, which thus bears the entire weight of the moving element.

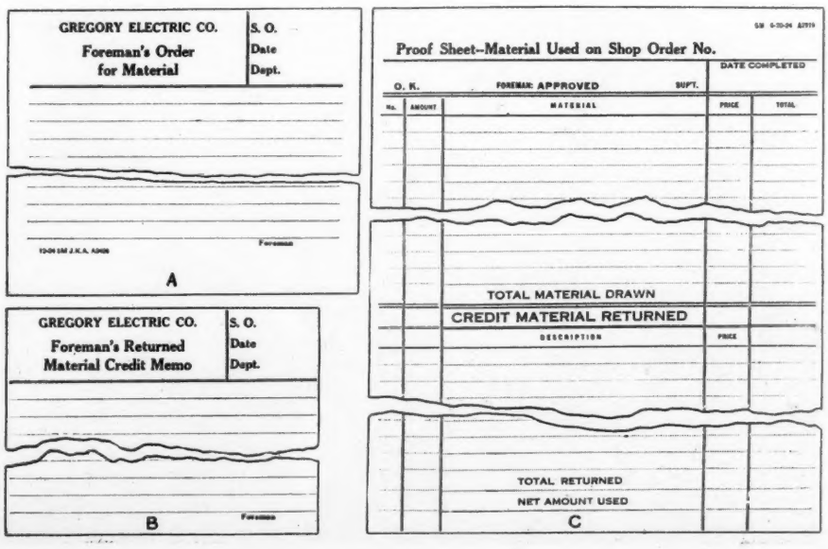
In the other type of pivot the end of the armature shaft is not turned down, but is rather sharply rounded, like the end of an egg, and rests on a cup-shaped sapphire jewel. In Westinghouse meters still another type of bearing is used. The armature shaft rests on a jewel which in turn rests on a very small steel ball supported on a cup-shaped jewel.

A radically different method of supporting the armature shaft is employed in Sangamo mercury-type meters. In these the shaft is supported on a disc immersed in mercury. In this case there is some thrust against the upper bearing, which is made up of a ring-jewel and endstone.

In the course of time, and particularly if they are not oiled occasionally, pivots become rough and worn and require polishing. This operation is performed by chucking the shaft in a small lathe, similar to those used by jewelers, and grinding the pivot smooth with a fine oil stone. Then it is polished with worn crocus cloth and the final finish given by polishing it with a piece of leather. As a rule the upper bearing, except in Sangamo meters, does not require any particular attention. In Sangamo meters, as noted before, the upper bearing is of substantially

Fig. 3—When material is withdrawn from or returned to the storeroom these forms are used.

Supplies are given out by the storekeeper only on receipt of the form shown in *A*, which bears the shop order number of the job. The storekeeper sends these tickets to the office and enters on the upper part of *C*, which is held by the foreman, the kind and quantity of material disbursed. If the foreman of the Meter Department wishes to return any material for credit, he sends it back to the storeroom with the ticket shown at *B*. The storekeeper then gives this department credit for the returned material by making the proper entries at the bottom of form *C*. The amount of material used on any job is thus easily found. When the job is completed the forms are sent to the office and filed under the job number.



the same construction as the lower bearing in many of the other meters, and receives the same treatment.

If the meter is of the commutator type the commutator is, if necessary, smoothed down with very fine, worn crocus cloth and polished with silk tape. The brushes are similarly smoothed and polished.

Although the jewels are extremely hard, they are also brittle and for that reason are usually broken if the meter is dropped or otherwise roughly handled. We inspect the jewels carefully and if they are damaged in any way they are replaced with new ones obtained from the manufacturer.

If the current or potential coils, shunt, resistance and the like are damaged or burned out we replace them with new parts supplied by the manufacturer of the meter. We do not attempt to wind our own coils, as we find that little or nothing is gained by so doing, although we are equipped to make almost any part that might be needed, with the exception of jewels. In this way every part of the meter is carefully gone over and any repairs or replacements necessary to put the meter in first-class shape are made.

It is, of course, necessary to keep track of the material used and the time spent in making repairs, and we have a simple but efficient system for doing this. Every job has an order number against which all time and material are charged. Material is requisitioned from the storeroom on the form shown in Fig. 3, *A*. As these tickets come in the storekeeper enters the kind and amount of material called for on the form shown in Fig. 3, *C*. Any material which the foreman of the *Meter Department* wishes to return to the storeroom is sent back along with the form in Fig. 3 *B*. The proper entries are then made at the bottom of the form in Fig. 3 *C*. When the job is completed all of the tickets are turned in to the office and filed under the order number. The time tickets turned in by the men bear the order number of the jobs they have worked on. In the office the entries on the time and material tickets are transferred to a cost sheet, from which the entire cost of any job may be obtained.

After all repairs have been made, assembly and testing of the meter are then in order. For present purposes the only point in the assembly which needs to be mentioned is the oiling of the jewel bearings. It is highly important that only the finest grade of clock or meter oil be used for this purpose. Inferior oils will soon become gummy and cause the meter to run slow.

Testing watt-hour meters is, of course, one of the most important steps in the overhauling process. Unless a meter is properly adjusted it will not function properly, no matter how carefully the repair work may have been done. Testing is a subject about which a great deal could be said, but at this time it is possible to indicate only some of the more important points.

As everyone knows, there are three general methods of testing watt-hour meters: namely, (1) by the use of indicating instruments; (2) by comparison with rotating standards; and (3) by the use of a calibrated resistance. We use the first-named method wherein, in the case of direct-current meters, the power passing through the meter is measured by an ammeter and a voltmeter and the time required for the moving element to make a certain number of revolutions is determined with a stop watch.

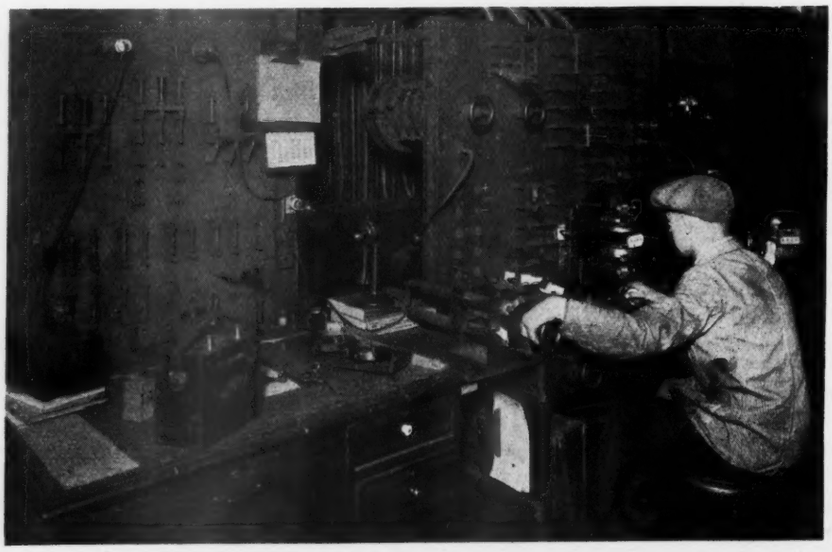
First we always check the dial register and gear ratio, to see that these are correct. We know that the moving element of a given meter should make a certain number of revolutions per minute when a certain amount of power is passing through the meter. When making a test, therefore, we put on the meter a load corresponding to full load, and the time required for the moving element to make ten revolutions or so, depending on the constant, is noted. At this time the meter is, of course, going too fast or too slow. If it is going too fast, that is, if the time required for the given number of revolutions is less than it should be, the drag magnets are moved slightly outward, or away from the shaft, to increase the retarding effect and thus slow down the meter. Conversely, if the meter is going too slowly, the drag magnets are moved in toward the shaft. The test is then repeated and the magnets again adjusted until the moving element rotates at the proper speed. The load is then decreased to 10 per cent of the full-load rating of the meter and the tests again repeated, with such adjustments as may be necessary, until the moving element is rotating at the proper speed at this load.

The meter is then tested for creeping, which is a slow rotation of the moving element when there is no load on the meter. In general, creeping may be due to one or more of the following causes: (1) Incorrect compensation for friction. (2) Vibration, which may reduce the friction sufficiently to cause rotation. (3) Stray fields. (4) Too high voltage. (5) In the case of three-wire meters connecting the potential circuit on the load side of meter when

(Please turn to page 259)

Fig. 4—Testing a polyphase watt-meter after overhauling.

The tester is checking each phase separately by taking with a stop watch the time required for the moving element to make a certain number of revolutions while full-load current, as shown by an indicating wattmeter, is being passed through the meter. From these test boards current of any desired voltage, frequency or number of phases can be obtained. Power is supplied by a number of motor-generator sets, not shown here.



SLING CHAINS are most frequently overloaded because the men using them are either careless or ignorant of how they are abusing them. Comparatively few men realize that they can overload a chain when lifting a weight much below the rated safe working load of the chain. How this is possible is only one of the important considerations in chain service which are taken up in this article.

Some of the More Common

Ways in Which Sling Chains Are Abused

Together With a Short Discussion of Some Important Principles of Chain Loading Which Are Often Misunderstood or Overlooked in Practice

By DAVID FLIEGELMAN

Chain Design Division, American Chain Co., Bridgeport, Conn.

ASSURANCE that the chain is of ample size is perhaps the most important consideration when selecting chains to be used for hoisting heavy loads. This includes chains used on slings, cranes, dredgers and on other similar work where the chain is subjected to extremely severe usage. Manufacturers of chains give a safe working load rating which should not be exceeded.

In other words, a chain should be ordered sufficiently heavy for the work it is to do and at no future time should it be put to more severe use. It is not enough to know that the load lifted is below the safe load for that chain. There are other ways in which the safe load of a chain may be exceeded, even though the weight lifted is below the rated load. How that may be done will be explained later in this article.

In plants where human life may be endangered or where expensive machinery may be damaged by falling loads, chain manufacturers usually recommend dredge-quality, wrought-iron chains for service. Steel chain is not ordinarily recommended for use where loads are handled above the heads of workmen, or in other places where a dropped load would be dangerous. In some places where no particular hazard is involved, a steel chain may be used with entire satisfaction.

The reliability of any chain depends upon the quality of the welds and the material of which it is made. Because of the physical characteristics, which will permit the chain to suffer considerable abuse before fracture occurs, wrought iron is the best material to use. The quality of the iron can be obtained from laboratory tests; the quality of the welding is indicated by the "proof test" and careful inspection.

Chain should be proof-tested before using, as no chain is safe unless so tested. This is usually done by the manufacturer, who will furnish a certificate to that effect whenever requested to do so. The proof-test consists simply in applying a test load which is above the safe working load. This stress will be below the yield point of the metal but high enough to open any improperly welded links. High proof-tests deform the links and strain the material so that the shock-resisting qualities of the chain are depreciated. The safe working load rating of the chain would ordinarily be considerably below the load to which the chain has been proof-tested. Careful inspection after proof-testing will indicate any cracks or other signs of poor welds which did not show up beforehand.

Overloading is perhaps the most serious service abuse to which chains may be subjected. The strength of a chain may be seriously impaired by overloading it. Overloading has no relation to the age of a chain, as even a new chain may be impaired within a comparatively short time. The natural elasticity of the wrought iron is sufficient to take care of any proper or safe loading, if this is within the manufacturer's rating. If not overloaded or stressed beyond the limit of elasticity or yield point the chain will regain normal shape as soon as it is relieved of its load. When stressed beyond its yield point by an overload, the metal in the link does not go back to normal condition or shape after the load is removed. When the yield point of the metal is once passed by an overload the metal is never as strong as before.

Here the load is lifted without extra strain on the chain due to twisted links or to a wide angle between the branches of the sling. The National Safety Council, however, points out that the man at the right is endangered by using his hands to guide the chain.

Because of improper application the total actual stresses set up in the links may be far in excess of those due merely to the weight of the load lifted. These increases in stresses in the chain due to improper use of the chain often have more serious results than an actual overload. These increased stresses may be due to any of the following causes: (*a*) Sudden application of load, shocks and sudden jolts. (*b*) Twisting of chain, kinks in chain and crossing of chain. (*c*) Bending of links around sharp corners. (*d*) Large angles between the branches or legs of double sling chains.

Of all of these four ways of abusing sling chains, probably the one least understood and appreciated is the last. The table below shows the safe working load for double sling chains under various conditions of attaching the hook to the load. It will be noted in this that as the angle between the two chains increases and the angles between the chains and the load decreases a lower safe working load may be handled. This is because that as the angle increases between the two chains the tension in each branch of the sling increases. While this is easily understood by those who have studied mechanics or mathematics, it is somewhat difficult to explain. The drawing on page 227 will, however, illustrate how this load is increased in each branch of the sling, although it does not explain why nor wherefore.

The arms of the two men carrying the traveling bag represent a double sling chain (inverted) with one arm of each person taking the part of one branch of the sling. While the two men stand close together with their arms down straight and parallel, each carries one-half of the load without much effort or strain on the arm. However, as the men step farther apart, the angle between the arms increases and as it does so, the load or pull which each man must exert to hold the traveling bag in the position shown increases. The strain on the men in positions *E* and *F* would far exceed their ability to stand the strain. In the same way a chain is overloaded.

When the angle between the branches is 170 deg., or the angle between the chain and the load 5 deg., as shown in the right-hand column of the table at the right, the safe working load is only 10 per cent of the safe load when the chains are almost vertical. In other words, the stress in these chains, if the same load were lifted in each case, would be about 11½ times as great with the chains at a wide angle, as when the chains are vertical. Half of this load would be taken by each branch of the chain. However, this stress would exceed the factor of safety of three and one-half to four, which is ordinarily used in a chain. Thus the stress or overload may be great enough to rupture the chain even though a load much heavier could be handled with safety if the chain had been applied differently.

It will be noticed that when the angle between the chains is 120 deg., or the angle between the chain and the load 30 deg., that the stress on each chain is equal to the total load. This angle might be considered as the absolute maximum at which sling chains should be used, and a much smaller angle would be preferable.

Practically the only method of preventing any of these abuses of chains is to know the effect of them and exercise care to prevent them. An inexperienced man should not be assigned to the task of adjusting or placing chains on loads that are to be lifted.

Repeated overloading of chains produces fatigue which weakens the chain sufficiently so that it may break sometime later even though it is loaded below its safe working load. The unsafe condition of the chain does not always show up when the overload is applied. A good wrought-iron chain will usually indicate that it is in an unsafe condition before actually rupturing. One of the most obvious indications of an unsafe chain is elongation which may be due either to deformation of the links, or to inter-link wear.

Deformation of the links is due to overloading, which makes the links narrower and longer, and destroys their elliptical shape; consequently, the chain loses its shock-absorbing properties. Results of tests show that in consequence of the deformation of the links and strain or fatigue of the metal, the chain becomes brittle. The wear on the inner surfaces at the ends of the links, where they "bottom," is due to the

How Stresses Increase in Branches of Sling Chains

Angle Between Branches in Degrees	Ratio of Pull to That with Branches Vertical	Per Cent Increase of Pull over That with Branches Vertical
10	1.004	0.4
20	1.015	1.5
30	1.035	3.5
40	1.064	6.4
50	1.103	10
60	1.155	15
70	1.221	22
80	1.305	30
90	1.414	41
100	1.556	56
110	1.743	74
120	2.000	100
130	2.366	137
140	2.924	192
150	3.864	286
160	5.759	476
170	11.474	1,047

NOTE: When the chains are vertical the pull is equal to the load. As the angle between the branches of a double sling chain increases, the pull also increases in the ratios and percentages shown. Under ordinary conditions half of the load would be taken by each branch of the sling.

Safe Load in Pounds for Double Sling Chains Under Different Loading Conditions

SIZE OF CHAIN INCHES	SAFE LOAD FOR SINGLE CHAIN	WHEN USED AT 60° ANGLE	WHEN USED AT 45° ANGLE	WHEN USED AT 30° ANGLE	WHEN USED AT 20° ANGLE	WHEN USED AT 15° ANGLE	WHEN USED AT 10° ANGLE	WHEN USED AT 5° ANGLE
¼	1,100	1,900	1,550	1,100	750	570	380	190
⅜	2,700	4,700	3,800	2,700	1,850	1,450	940	470
½	4,500	7,800	6,350	4,500	3,100	2,300	1,570	780
⅝	6,900	12,000	9,750	6,900	4,700	3,550	2,400	1,200
¾	10,100	17,500	14,000	10,100	6,900	5,200	3,500	1,750
⅞	14,000	24,000	19,500	14,000	9600	7,250	4,900	2,400
1	18,600	32,000	26,000	18,600	12,700	9,650	6,500	3,200
1¼	28,800	50,000	40,500	28,800	19,700	15,000	10,000	5,000
1½	40,800	70,000	57,500	40,800	28,000	21,000	14,000	7,000
1¾	52,500	91,000	74,000	52,500	36,000	27,000	16,000	8,100
2	66,600	115,000	94,000	66,600	45,600	34,500	23,000	11,500

NOTE: The drawings in the heading show the application of the chains to the load. When the angle between the chain and the load is only 5 deg. the safe load is only 10 per cent of the safe load when the angle is 60 deg. This may be compared to the chart showing analogous loading between chains and men carrying a hand bag by subtracting the sum of the two angles indicated here from 180 deg. to give the angle between the two branches of the sling.

links rubbing against each other under load.

Any excessive wear decreases the cross-section of the metal at the ends of the links and so decreases the factor of safety of the chain. From the above we see that the result of overloading a chain is made evident by the elongation. In many shops, men are trained in the careful use of chains and are taught that only loads that do not stretch the chain are safe.

Some Easily Applied Methods of Inspecting Sling Chains

To detect elongation, the chain should be measured when new, before it is put into use and again measured at each inspection period. Either the overall length of the chain can be measured and recorded, or the chain can be measured off in 3-ft. sections, and marked off carefully by prick-punch marks.

It is recommended that chains in daily use and subjected to ordinary service should receive careful inspection about once in two or three weeks. If used for more severe or heavier duty they should be inspected more often. If chains are not used daily they may be inspected at such proportionately greater intervals as the experienced chain man may consider necessary.

Precautions to Take When Using Chain Slings

Don't overload a chain.

Don't apply a load to a chain suddenly.

Don't fasten chains over sharp corners or edges.

Don't cross a chain, twist it or put a kink in it.

Don't take chances; if a chain doesn't look safe or doesn't pass inspection, scrap it.

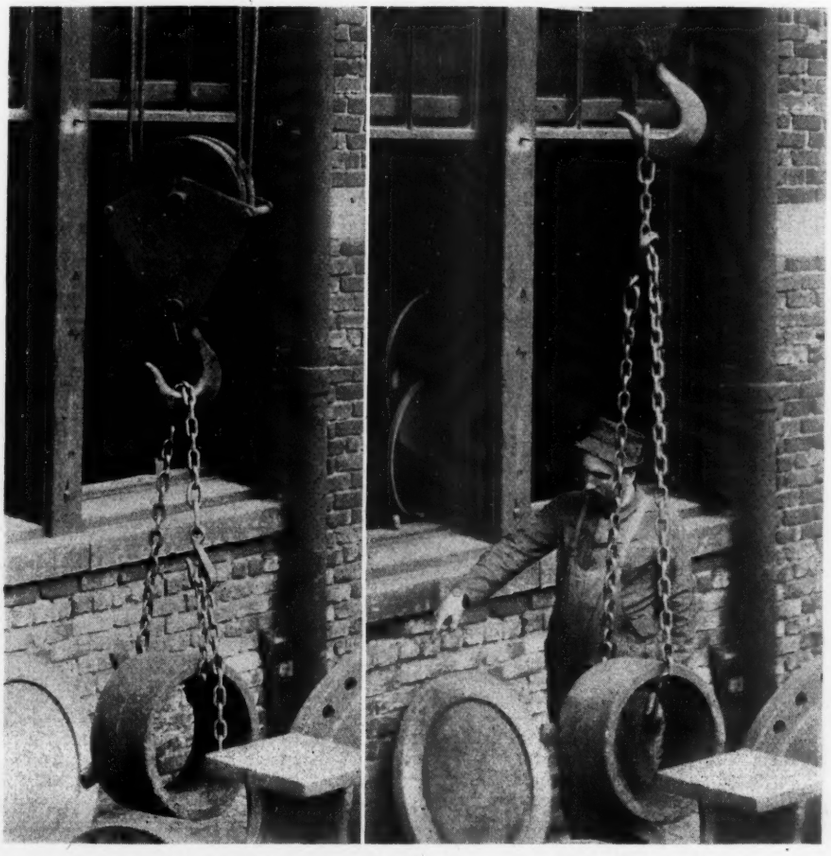
Don't forget constant and careful inspection.

Inspection consists in closely examining every link, hook and ring for defects. If any link or attachment shows a flaw, insecure weld, crack, fracture, or any other defect, the chain should be laid aside and marked unsafe. It should not be used again until the defective parts are taken out of the chain, and the chain is repaired. The chain should also be measured for elongation, having been measured or marked off when new, as described above. If any 3-ft. section has been found to be stretched considerably more than the remainder of the chain, that section, or still better, the whole chain should be condemned for that particular job.

Records should be kept of the results of inspections, and when they show that a succession of chains on a given job have all become considerably elongated, it is natural to infer that the service requires a chain with a higher factor of safety—in other words, a heavier chain. This system of periodic inspection has been found very effective in reducing chain failures. A chain that has been elongated on some particular job may still be safe to use on lighter service. Excessive elongation is the result of the careless use of the chain, and this should be corrected at once. If there is any appreciable wear at the ends of the links where they bottom, the chain should be considered unsafe, or the safe working load should be reduced until it is well within the safe working capacity for the weakened condition.

Some Points to Consider on Annealing Chains

Hoisting chains are usually subjected to severe usage and are, therefore, particularly liable to failure through fatigue, due to repeated shock or loading, and through overstrain due to overloading. Stretching of the chain due to overloading also tends to make the metal brittle. Annealing, when properly and carefully done, softens the metal sufficiently to relieve the internal strains, makes the chain less brittle, and allows it to stretch before breaking when overloaded. The sling chain hook should also be annealed with particular care, for when properly annealed, it will gradually yield and begin to straighten out, if overloaded, and thus give warning of possible danger. Chains and attachments should be inspected very carefully after annealing, as defects and flaws not visible before annealing may then show up. Many large foundries and railroad shops anneal



The right and the wrong methods of hooking up a single sling chain. The illustration at the left shows the correct method of using a single-sling chain to handle loads such as this. Here the sling is suspended from the middle of the burden hook and the grab hook is also properly fastened. In the illustration at the right, however, the ring of the chain is caught over the tip of the burden hook, even though it is too small to go onto the hook far enough to be safe. In such cases as this where the load is applied so far out on the tip of the hook an extra heavy load may straighten out the hook until the load may slip off. The hook is designed to carry the load down in the throat and not on the tip. Also, in this case, the grab hook is improperly fastened. These illustrations are used by courtesy of the National Safety Council, Chicago.

their chains at regular intervals by competent workmen, who know how to secure the desired results.

There does not seem to be as yet a recognized standard method of annealing chains, as evidenced by the different methods and temperatures employed by the large users of chains, who consider periodic annealing of some value.

Many other important factors enter into the problem of the proper annealing of chains; however, in general, annealing consists in heating the chain to a uniform temperature of between 1,500 deg. F. and 1,600 deg. F., keeping it at this heat only long enough to heat the chain throughout, and allowing it to cool freely in air.

It should also be remembered that every annealing operation lowers the breaking strength of the chain, and hence decreases the safe working load. Annealing does not eliminate the minute cracks in the metal caused by repeated overloading; nor does annealing restore an elongated chain to its original length. Rather than recommend the annealing of chain, we emphasize the importance of preventing the overloading of chains. Annealing is merely a means of partially compensating for abuse of a chain.

Fixing Responsibility for Care of Sling Chains

In every shop some particular person should be held responsible for the selection of the sling chains used for hoisting, and for making suitable hitches about the loads. Experience will have taught him to be able to select the proper sling quickly and intelligently, and to attach the sling, or to hook on to the load in the best and safest way.

When the load to be lifted has sharp corners or edges, they should be protected where the chains run over them; otherwise the sling or load, or both, may be damaged. Thick pads of burlap or other soft material or, still better, wooden protective corner pieces, made by nailing two blocks of wood together to form an L-shaped block which fits on to the corner of the load, are used to prevent the sling from being abraded as well as the load from being damaged.

A double sling chain should be sufficiently long to leave considerable space between the top of the load and the point of suspension of the sling. This is to keep the angle between the legs of the sling as small as possible, usually under 75 deg. except in unavoidable cases. The fact is often disregarded that the greater the angle between the legs or branches of the sling, the greater the stress in the links under an equal load. How much this stress increases with each increase in the angles is given in the table at the top of page 224.

It is only by careful inspection that an unsafe link such as this is found. Here the link shows excessive wear where it "bottoms" on the ring; also it is beginning to crack. This link would probably break on the first heavy load applied. The remainder of the chain looks as though it were in good shape and would have considerable useful life in it if this link were replaced.

Hooks on sling chains are sometimes forced into place by striking them with some heavy implement. This practice should be prohibited, as the hooks may thereby be dangerously weakened. The hooks should not be used so as to carry a load on their point. Hooks are not designed for such service and, if so used, are very likely to open up or break. Sling chains generally have a ring to hook into, or else the hook grabs the chain; that is, the chain passes through the belly of the hook. The point of the hook should never be inserted into a link.

The accompanying table shows the sizes of single and double slings recommended for various loads. The sizes of double sling chains are based on the assumptions that the angle between the legs is not over 75 deg. and that approximately one-half the load is carried by each leg. If either or both these conditions are not fulfilled, a suitably heavier size of chain should be used. If the load is of such a nature that one leg carries considerably more than the other, care must be taken that the leg carrying most of the load is not overloaded. One leg or branch of the sling may carry an undue proportion if the load is not applied properly.

On chain hoists, where the chain passes over a wheel which has a rather small diameter, there is an excessive movement or rubbing of the links at the ends where they bottom. If the chain carries a heavy load, the wear at the point of bottoming may be excessive. This wear results in a reduced section at the ends of the links, and the factor of safety of the chain is therefore reduced. To prevent this wear, the diameter of a chain wheel should be about 24 times the size of the chain, and never under 12 times, if it can be avoided. There may occur conditions when it is inadvisable to increase the present size of a small wheel; in such cases the chain

Sizes of Sling Chains Recommended for Given Loads

Load Pounds	Single Sling Inches	Double Sling Inches	Load Pounds	Single Sling Inches	Double Sling Inches
1,125	1/4	...	22,400	1 1/8	7/8
1,700	5/16	1/4	28,800	1 1/4	1
2,700	3/8	5/16	34,500	1 3/8	1 1/8
3,450	7/16	3/8	40,800	1 1/2	1 1/4
4,325	1/2	3/8	46,100	1 5/8	1 1/4
5,525	9/16	7/16	52,500	1 3/4	1 3/8
6,925	5/8	1/2	58,500	1 7/8	1 1/2
8,550	11/16	9/16	66,000	2	1 5/8
10,150	3/4	5/8	74,400	...	1 5/8
12,250	13/16	11/16	84,000	...	1 3/4
14,000	7/8	3/4	93,600	...	1 7/8
18,600	1	13/16	107,000	...	2

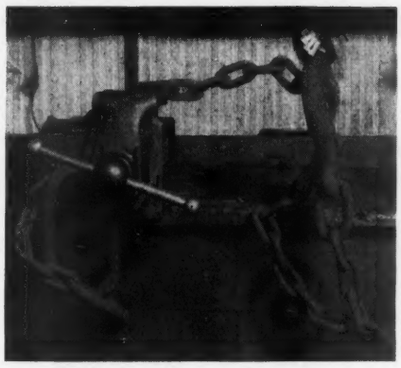
NOTE: Sizes of double sling chains made from dredge chain are based on the assumption that the angle between the two legs is not over 75 deg. and that approximately one-half the load is carried by each leg. If these conditions are exceeded, a heavier size of chain should be used.

should be replaced by a new one as soon as it shows any appreciable wear. The size of a chain is determined by the diameter of the metal used to form the link.

When a block or pocket-wheel chain has become stretched, due to overloading or to wear, the links no longer fit the wheel. The only remedy is to install a new chain. When a chain is removed from a wheel to be repaired, it is essential that the chain be replaced so that the links lie in the same plane as they did before being removed. Observance of this rule will add considerably to the life of the chain. By marking a few of the links before removing the chain from the wheel, this can be easily accomplished. Obviously the chain should not be twisted when replaced.

Keep chains clean and free from grit, which causes rapid wear at the ends where the links bottom. This wear can be decreased by oiling the bearing surfaces between the links. In fact, frequent oiling of the complete chain will not only prolong the life of the chain, but will also prevent rusting. However, oil should be used sparingly on hoisting chains operating in places where the air contains gritty or abrasive material. The oil will simply catch the dust and hold it.

Chains for hoisting or for slings, like any other kind of industrial equipment, must be handled properly to insure long life and satisfactory service. Of all the abuses, overloading is the most serious not only because of the damage to the chain but also because of the serious accidents which may result when an overstrained chain gives way. There is no telling where the load will drop.

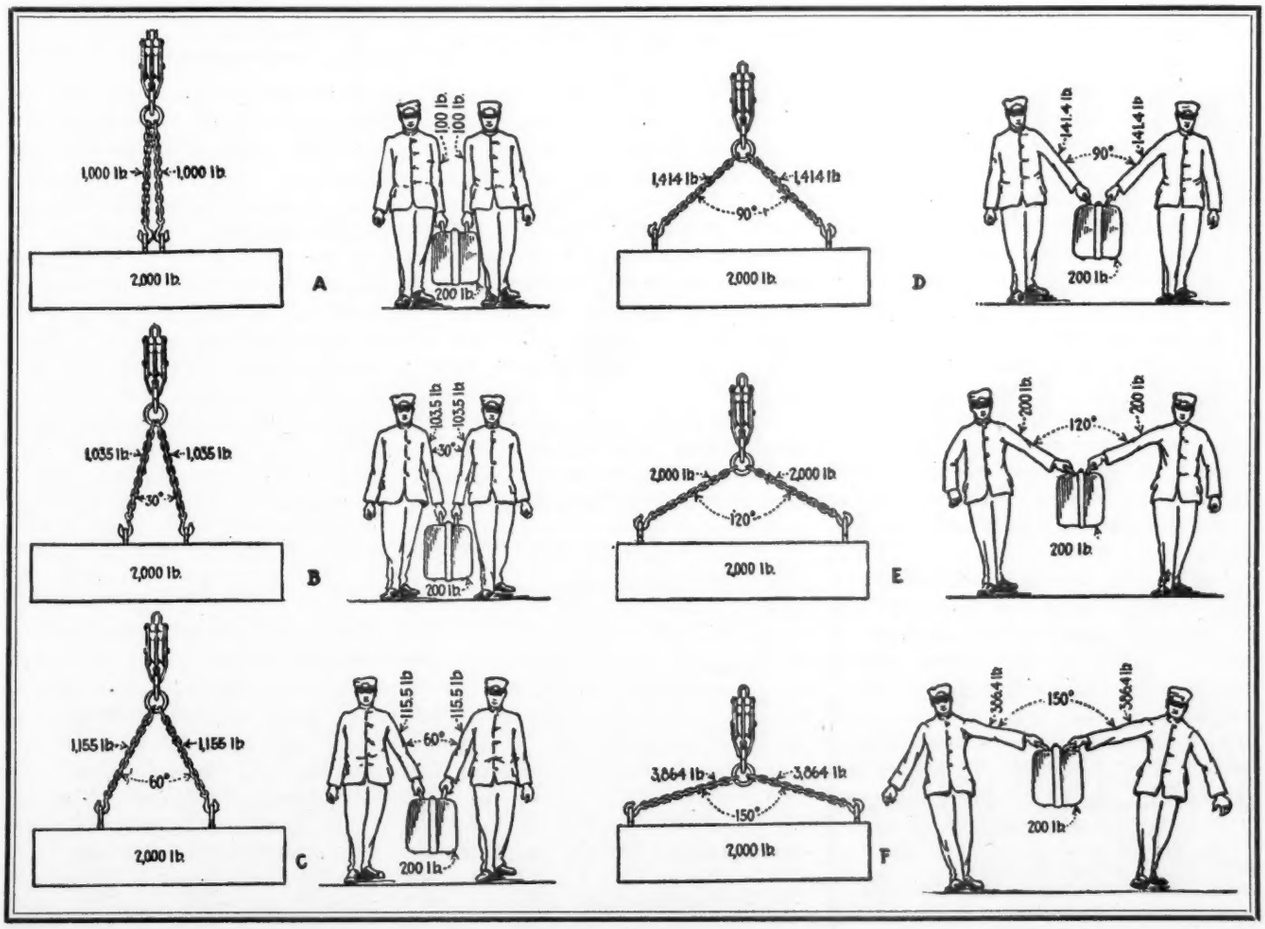


This chain has been permanently damaged by overloading.

Overloading chains until they stretch causes the links to lock so that the chain becomes stiff. This chain has been so heavily overloaded that the links are no longer pliable. The entire weight of the chain is supported by the seven horizontal links held in the vise. Other links below the hook in the illustration are also locked because of stretching. In this case the damage is largely confined to one branch of the chain. This may be due to the fact that the entire load was at times lifted by one chain instead of using the double sling.

Although these drawings do not explain "Why," they show how the branches of a double-sling chain may be overloaded, and in a manner which can be easily understood.

The load on the two chains and the strain on the arms of the two men carrying the handbag are similar. It will be noticed that as the arms of the two men are practically vertical each carries approximately half the weight. However, as the angle between them increases, the pull or strain on their arms also increases. As long as this angle is of moderate size the increase is not important because a chain has a factor of safety which will take care of the slight increase in load. However, at 120 deg. the pull on each chain equals the total load. The pull is excessive at 170 deg., where each of the branches takes a stress approximately 5¾ times the original load. Ordinarily, the factor of safety in a chain is somewhere between three and four times its safe working load. The angle between the branches should never be over 120 deg., as even at that point the chain is under a stress of twice as much as the weight of the load. An accompanying table shows the safe working load of chains at various angles. An angle of 75 deg. is the maximum recommended.



Here Are the Details of a

Fuse Color Scheme That Prevents Misuse of Fuses

Together With an Analysis of the Causes of Improper Use and the Methods That Can Be Used to Correct the Trouble

By CHARLES R. HEPNER
Chief Electrician, Willard Storage Battery Co., Cleveland, Ohio

"INVESTIGATION showed that our fuse troubles were due to our own carelessness (and we are perfectly frank in calling it carelessness) and that they could be attributed to the following causes: (1) Fuses with the paper sticker off; (2) fuses in the wrong bin although properly labeled; (3) fuses refilled to a capacity other than that indicated by the sticker; (4) fuses refilled improperly; (5) fuses blown but put into the stock bins; and (6) over-fused apparatus."

In these words Mr. Hepner tells what was disclosed by a careful study of the methods of handling and using fuses, in an endeavor to eliminate the troubles which were being experienced. In the accompanying article he analyzes the causes and results of the conditions which were found and explains the plan that he used to overcome them in the plants of the Peerless Motor Car Company and the Willard Storage Battery Company.

ABOUT seven or eight years ago, after several years spent in maintaining the equipment in a large plant where the aim of the *Electrical Department* was to keep the motor outages down to the lowest possible point, I became convinced that a great deal of our trouble was of our own making. As proof that my diagnosis was correct, we finally arrived at the point where we carried the plant along for several years with no motor outages over eight minutes in duration.

A great deal of this successful operation I attribute to the fact that we decided, after considerable investigation and thought, that most of our troubles were due to improper handling and misuse of our best friend, our safety valve, the fuse. I found that there were many contributing factors to this improper handling and misuse of the fuse.

As is generally the case in most shops, we kept our fuses in drawers or bins, the various sizes being kept in regular order. For instance, the 10, 15, 20, 25, and 30-amp. N. E. C. cartridge fuses were kept in five bins which were placed in a row side by side. The 60-amp. cartridge fuses refilled for various ratings were kept nearby.

Our investigation showed that our fuse troubles were due to our own carelessness (and we are perfectly frank in calling it carelessness) and that they could be attributed to the following causes:

(1) Fuses with the paper sticker off.
(2) Fuses in the wrong bin, although properly labeled.
(3) Fuses refilled to a capacity other than that indicated by the sticker.
(4) Fuses refilled improperly.
(5) Fuses blown but put into the stock bins.
(6) Overfused apparatus.

I am sure that you will agree with me in using the term carelessness after you give these remarks a little consideration. For instance it may not necessarily be due to carelessness that a sticker is lost from a cartridge, but it is carelessness, pure and simple, to take it for granted that a fuse is a 10-amp. fuse just because it is in the 10-amp. fuse bin. Again, it is carelessness when a blown fuse is accidentally returned to the stock bin with some good fuses, because the maintenance man forgot to test them out.

Let us consider in detail some of the troubles that our investigation showed were causing the misuse of fuses.

(1) Fuses with the Paper Sticker Off.—There are quite a few things that can and do happen because our friend the fuse has lost his identity. One man will pick up the fuse and on seeing no identification mark will toss it into the 30-amp. bin with the remark, "Well, if it isn't a 30 it will blow and the motor will be protected anyway."

But, he doesn't stop to think that when that fuse does blow because it is not a 30 and is inserted where a 30 ought to be, it means much more than the price of a fuse. It means a motor down longer than necessary; it means one or more men out of work longer than necessary; it means that production is held up longer than necessary; it means friction between the production and the maintenance departments; it means loss of profit to the firm; and it means a loss of bonus to the men. So you see, it means a great deal more than just the price of a fuse. And all because a sticker was lost from a fuse cartridge.

Another man will look at the fuse without a sticker and he will say, "I'll put it in the 10-amp. bin, for if it is heavier it will carry the load

Color Scheme for Indicating Size of Fuse

Size of Cartridge	Ampere Rating of Fuse				
	Black	White	Yellow	Blue	Green
1 to 30 amp.	10	15	20	25	30
35 to 60 amp.	35	40	45	50	60
65 to 100 amp.	65	75	80	90	100
110 to 200 amp.	110	125	150	175	200
225 to 400 amp.	225	250	300	350	400
450 to 600 amp.	450	500	525	550	600

without blowing." But he doesn't realize that if it happens to be a 30-amp. fuse that is inserted where a 10-amp. fuse ought to be, it will probably result in a burned-out piece of apparatus. This in turn means more expense and loss than in the previous case, for it entails changing motors and possibly rewinding one. It takes time and money to replace and repair a burned-out motor.

If a careful man happens to get the fuse with the sticker off he will take it apart and find out for sure just what size it is; but this again is a waste of time.

(2) Fuses Properly Labeled but in Wrong Bins.—It happens frequently that a fuse will get over the partition into the wrong bin. For instance, when a man is putting a lot of 15-amp. fuses into the correct bin, one of them may accidentally fall over into the 20-amp. bin and the maintenance man will take it to be a 20 because it is in the 20-amp. bin. Or if it falls into the 10-amp. bin it will be mistaken for a 10. So you see the same conditions arise as in the case where the sticker is lost from the cartridge.

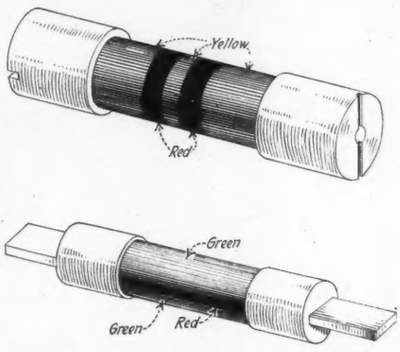
(3) Fuses Refilled to a Rating Other Than Indicated by the Sticker.—Of course, it is to be expected that when a fuse is refilled to a rating other than indicated by the sticker, the man refilling it will mark the rating on the case; but sometimes we all forget. So again we have the same conditions as when the sticker is lost, only in this case we are misled by the marking.

(4) Fuses Refilled Improperly.—Unless care was exercised in choosing the man to refill the fuses, we found that the refills would be put into a cartridge without cleaning up the contacts; or the fastening screws would be left loose; or the refills would be twisted and partly torn. These troubles can be overcome only by selecting competent and trustworthy men to do the refilling.

(5) Blown Fuses Put in Stock Bins.—Our investigation showed that frequently the trouble shooter would, when returning fuses to the bins, put a burned-out fuse in the bins along with the good ones. This necessitated testing each fuse when it was taken out of the bin. This is, of course, a waste of time, as all fuses in the bins should be O. K.

(6) Apparatus Overfused.—We found also that the custom or habit of the ordinary electrician, when removing a burned-out fuse, is to put in one just a little bit heavier. This is done because he thinks that the motor is carrying a load up to the capacity of the fuse and he doesn't want any more fuses to blow in this motor line. This practice results in the circuits gradually becoming overfused, so that they are no longer protected by the fuses.

In order to overcome the troubles brought to light by our investigation, we decided to adopt the following scheme: (1) All fuses to be refilled and put in stock by one responsible man; (2) records kept of all fuse outages; (3) installation of a color scheme for fuses.



Scheme used for indicating underfusing or overfusing of a cartridge.

If a fuse is refilled with links below the rating of the cartridge, lengthwise red stripes are painted on the cartridge, as shown in the top illustration. Each stripe indicates that the fuse is one size smaller than that given for the main color of the fuse as indicated in the accompanying table. If larger than rated refills are used in a cartridge, red rings are painted on it, as shown in the bottom illustration. Each ring indicates one size larger than the rating for that color as shown in the table. For instance, a 200-amp. cartridge having the barrel painted yellow with one red ring around it, would indicate that the fuse had refills in it to make it blow at 300 amp. instead of 200 amp., which would be the case if no red ring were painted around the barrel.

One man on whom we could rely was delegated to inspect all fuses on hand, to do all refilling, and to have charge of the painting of the cases.

A survey of our plant was then made and the various apparatus was carefully fused according to its demand. A record of this was made for future reference. Each time a fuse is replaced for any reason, a report is made showing the rating of the fuse taken out, the rating of the fuse put in, and the cause of the change. If the rating of the fuse was changed, a satisfactory reason must be given. This stopped the practice of putting in fuses of higher rating without adequate reason therefor.

To overcome the troubles due to the first three causes listed before we decided upon a color scheme for the fuses. Five colors—black, white, yellow, blue and green—were chosen for the base colors, with red for a danger sign.

For instance, we took a 10-amp. cartridge, scraped the paper sticker off and painted the barrel black. We also painted the 10-amp. fuse bin black. The 15-amp. cartridge and bin were painted white, and so on.

A light blue must be used to keep this color from getting confused with the black when the blue gets dirty.

The accompanying table shows the sizes we chose to use and as they cover the range of sizes pretty thoroughly, we have no trouble in properly distinguishing with the five base colors, the fuses which it is necessary to keep on hand. A great many times it is convenient to underfuse a cartridge. For instance, we may have a 200-amp. fuse block and want only a 100-amp. fuse in the circuit. To provide for this emergency, we take a green 200-amp. cartridge and refill it for 100 amp. A red stripe is then painted along the cartridge from one end to the other. If this same fuse were refilled for 60 amp., two stripes would be painted on the cartridge and the cartridge would be placed in the fuse block with the stripes facing out, so that it could be seen at a glance that the fuse was underloaded. One stripe is used for each variation in size of cartridge. Reference to the accompanying table will show that a 200-amp. fuse in a 200-amp. size case would be painted green.

If a red stripe is painted on the green case, it indicates that the fuse link in the 200-amp. case is the next size smaller than that shown in the green column of the table; that is, it is a 100-amp. link. If there are two red stripes painted on the green case, it would indicate that the fuse link was two sizes smaller than the 200-amp. size given in the green column; that is, it would be a 60-amp. link. This scheme of striping is shown in the accompanying illustration.

Sometimes it is necessary to overfuse cartridges and in this case a red stripe or ring is painted around the center of the cartridge. One ring is used for each variation in size of cartridge. For instance, if we have a 60-amp. fuse block and want to put in 150-amp. fuses, we would take cartridges painted

(Please turn to page 260)

MACHINE WINDING of fractional horsepower, universal and other small armatures, as contrasted with hand winding, presents important advantages in the way of saving in time, uniformity of winding and lessened danger of short-circuits and other defects or injury caused by pounding. In this article Mr. Chapman describes the procedure involved in winding small armatures by machine and gives some helpful suggestions on various phases of the work, including the connecting of the leads to the commutator.

Some Practical Pointers on

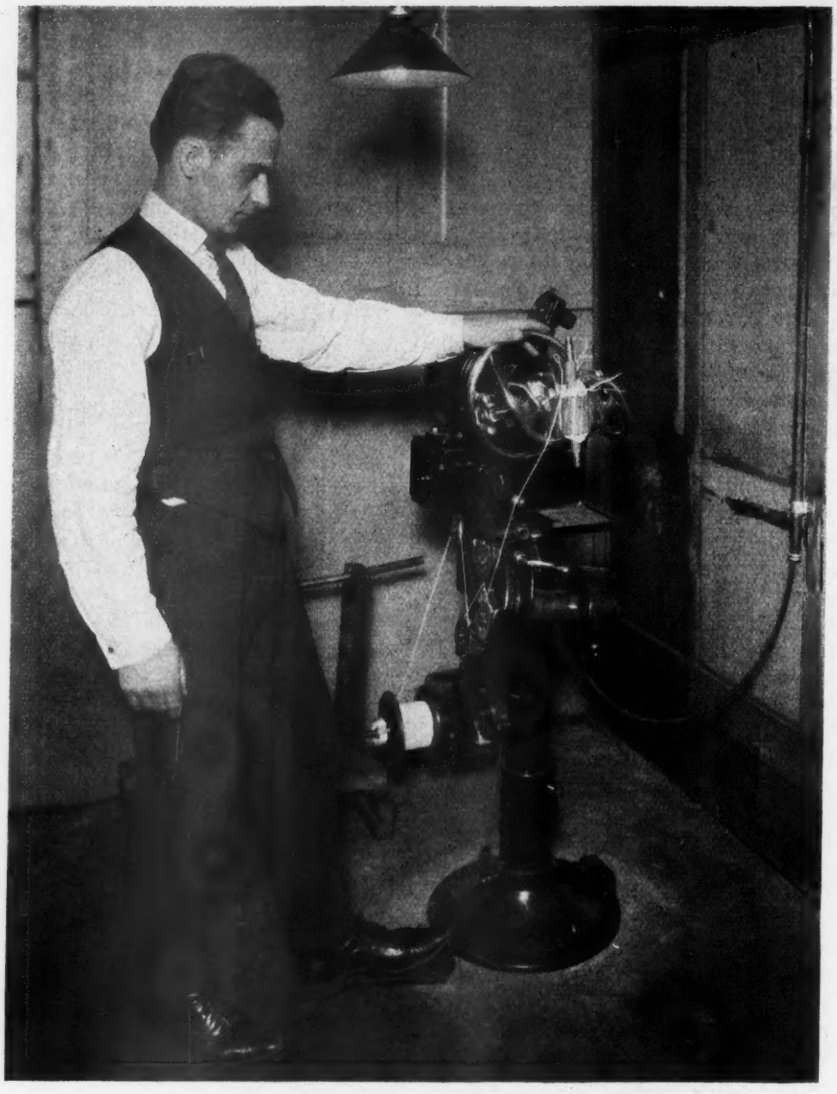
Winding Armatures by Machine

Together with Methods of Insulating the Core and Connecting Leads to the Commutator

By P. E. CHAPMAN
President, P. E. Chapman Electrical Works, St. Louis, Mo.

PRACTICALLY all small armatures coming within the classes known as fractional horsepower, fan, and universal, as well as some automobile generator armatures, are best wound by machine. Machine windings have the advantages that they are more nearly parallel, take up less space, are more free from short-circuits and other defects, and may be put on many times faster than by hand. In view of the very large number of small motors that are in use, a brief description of the principles and methods of operating armature winding machines may be interesting.

There are two distinct types of armature winding machines. The first is a fixed-size machine which will take only one size of armature, although it will handle any of the various windings usually put on the same armature core, for example, 32-, 110- or 220-volt windings. Such machines are, of course, suitable only for factories where the production of one size of armature is large. Machines of this type are usually double-ended; that is, they have a headstock and tailstock.



The operator of this armature winding machine has stopped it with one of the coils about half wound on. The turn-counting device may be seen just above his left hand. As will be noticed, the driving motor is controlled by the foot lever. The hand wheel, on which the operator's left hand is resting, serves as a brake and is used for putting on the last one or two turns.

Although there are several different makes of adjustable-type machines which can be used for winding the classes of armatures mentioned above, the descriptions and directions will apply in a general way to all of these machines.

Contrary to what might be expected, armature winding machines are of comparatively simple construction. For example, the Chapman bipolar drum armature winding machine, which is representative of this class of machines, consists essentially of a winding head which is mounted directly on the shaft of the driving motor. As will be seen from some of the illustrations, there are two jaws which are adjustable and serve to hold the armature core firmly while the coils are being wound on. Curved wings guide the wire into the slots. A counter mounted at the side of the driving motor keeps track of the number of turns wound on.

The wire, which is wound on spools, passes through a tension device which maintains the tension uniform and at the desired value, and permits quick starting and stopping without stretching the wire or allowing it to keep on unwinding after the machine is stopped. A general view of this machine is shown in the illustration at the beginning of this article.

Before an armature is stripped for rewinding, certain data should be taken and kept for reference, unless these data are already on file. The data required for rewinding small armatures are similar to that needed when working on large armatures

and should include the following items:

(1) Nameplate rating of the motor or generator.
(2) Number of turns of wire per coil.
(3) Number of coils per slot, or bundle.
(4) Size of wire.
(5) Kind of covering, or insulation.
(6) Span of the coil; that is, number of teeth a coil surrounds, or the number of slots per coil, which is usually counted as one more than the number of teeth enclosed.

It is advisable to take the following data also:

(1) Total number of armature slots.
(2) Total number of sections in the commutator.
(3) Position of the commutator with reference to some fixed point, as the shoulder of the shaft.
(4) Weight of wire.

Some good pointers on stripping armatures can be obtained from an article, "Ten Men Can Rewind 2,000 Armatures per Month" in the March, 1922, issue of INDUSTRIAL ENGINEER. It is always wise when stripping an armature to preserve the fiber heads, if possible.

Before rewinding it is, of course, necessary to insulate the core, which operation was covered in considerable detail in the article, "How to Wind Fractional Horsepower D. C. Motors," in the January, 1922, issue of INDUSTRIAL ENGINEER. I consider the continuous strip method of insulating to be the best. This is carried out by taking a long strip of some form of tough paper and fitting it either with or without the aid of pegs around the inside of the slots and over the teeth all of the way around the armature. A good, tough paper, such as was originally known as Leatheroid, and which can now be had under many other names, is the best. Papers of this character will hold their shape and eliminate the necessity of tying or sticking the insulation in the slots.

For strictly production work where the slots are not filled too full, cutting the slot insulation to the exact size and if necessary forming it in a hot die, is by all means the fastest method of insulating the slots. The grain of the paper should always run around the slot.

The method, which is sometimes used, of cutting short pieces of insulation and allowing the edges to stick out of the slots, is not to be recommended, as these edges require too much attention.

Wire with any kind of covering can be wound on by machine, but armatures should never be wound with anything but double-covered wire, as they will not stand up well in service. Wire with single insulation is only suitable for winding magnet and field coils, and it is not suitable even for these purposes when the wire is fairly large, say No. 12 B. & S., and coarser.

Enameled wires may, in general, be considered as equivalent to single-covered wires and should never be used, without another covering of some kind, for winding armatures. When rewinding an armature which was formerly wound with plain enameled wire, it is better to sacrifice somewhere else on the motor and use a double-covered wire on the armature.

So far as armature work is concerned, double-covered wires may be classified in the order of their heat-resisting and mechanically desirable properties, and their range of usefulness for random windings, placed directly on the armature core, about as follows:

TYPES OF COVERING	USUAL SIZES
Double cotton	Nos. 12 to 28 or 30
Cotton and enamel	Nos. 12 to 28 or 30
Silk and enamel	No. 28 and finer
Double cotton and enamel	No. 20 and coarser
Triple cotton	No. 20 and coarser
Silk, not used in sizes above	No. 20

Silk-covered wires are the most delicate, stand less heat and burn out quickest by slow roasting, but take the least room. They are highly useful where a large number of turns of fine sizes are required, and when cotton-covered wire would require an excessive volume in the slots. Both silk and silk-covered, enameled wires should by all means be avoided for armature work, in sizes coarser than about No. 27 or 28 B. & S. gage. Above this size they are very delicate and have to be insulated between coils and sometimes between layers.

Armatures wound with No. 20 and smaller wire are usually wound "random"; that is, not in layers and without auxiliary insulation between coils, as there is enough "cushioning" in these sizes to prevent me-

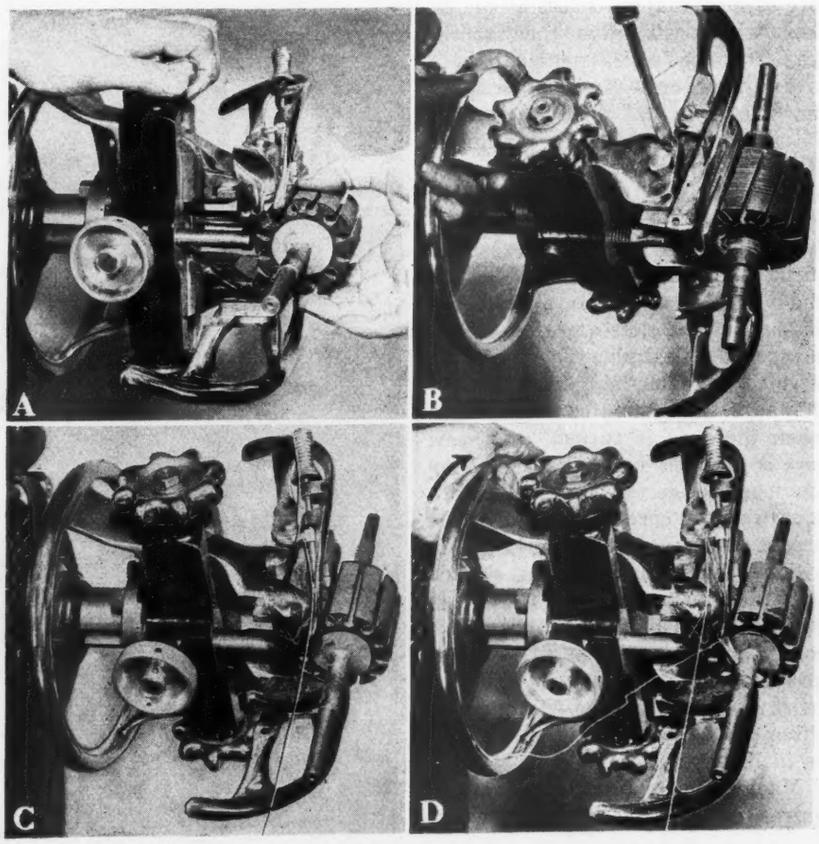


Fig. 1. These illustrations show how the core is placed in the jaws of the machine and the first coil wound on.

As shown in *A*, the core is firmly held by clamping the jaws on two slots which will give the proper span for the coils. When cores with skewed slots are being wound, as in *B*, the jaws must be adjusted to match the angle of the slots. In *C*, the wire has been given a turn around the snubbing pin in order to hold it against the winding tension. *D* shows an armature with more than one coil per slot. The first lead has been removed from the snubbing pin and the second coil will then be wound on.

chanical shorts. Modern baking varnishes will give the coils sufficient dielectric strength to permit satisfactory service at voltages up to 220 volts.

Armatures that have to be wound with wire coarser than No. 20 B. & S. gage should have insulation inserted between the coils, or be wound with triple-covered wires. Or they may be wound in layers, or wound on forms and assembled with auxiliary insulation between the coils on the heads. Auxiliary insulation is required for mechanical reasons on all small armatures wound with coarse wire, No. 20 and larger. This is particularly true of cotton-covered and enameled wires, as they are very deceptive and apparently sound armatures will sometimes break down in a few weeks. Instances are known where 60 per cent of the entire output of a shop has broken down in three months for lack of this insulation between coils on the heads.

Procedure When Using Armature Winding Machine

After the cores have been properly prepared and the slot insulation has been put in place, the next operation is winding the core. When placing the core in the winding machine, point the commutator end of the core toward you and select a pair of slots which will give the correct span for the coils, spotting them with the thumb and fingers, as shown in Fig. 1 *A*. Set the core in the jaws with their edges aligned. The jaws should overhang the edge of the slot about 0.005 to 0.010 in., or the thickness of a business card.

When setting open-slot cores, set about one-half the width of the slot under the jaws; that is, allow about one-half of the slot to project. This is especially desirable when the core is small in diameter. In order that this adjustment may be readily kept when the core is turned, or a new core is inserted, move the depth stop against the core. This will both square up the core and hold it at the proper depth.

Some armatures have skewed slots, and many that are apparently straight are a little off. When such cores are encountered it will be necessary to compensate for the twist by adjusting the winding machine jaws to match the slot angle, as in Fig. 1 *B*.

Machine armature winding requires considerable tension on the wire, more than is needed for winding plain coils, as the wire is pulled into place rather than pushed or pounded, as in hand winding. The best all-around tension is about 1⅛ lb. per 100 circ. mils of wire area. To illustrate, suppose we are winding an armature with No. 27 B. & S. gage wire. This size wire has an area of 202 circ. mils and would, therefore, have 2¼ lb. tension put on it. This tension will not stretch the wire, but will pull it into place nicely. Armatures are occasionally encountered which require that the wire be stretched in winding, but it is bad practice to do this.

In any case the tension required is so high that some form of tension device is necessary. It is almost impossible to get this tension by hand and even if it were possible to obtain it, the tension would not be uniform and the speed of operation would have to be reduced considerably, while a good deal of extra pounding would be required.

A successful reel holder and tension device will require that the inertia of the spool at starting, which is frequently sufficient to break the wire, be compensated for. It is necessary that the momentum at stopping be overcome and the slack taken up. In the case of No. 28 B. & S. gage and larger wire, auxiliary tension must be applied to the wire for it is not safe to put so much tension on the spool, as the delivering turn will frequently cut down into the remaining wire and snarl up. This auxiliary tension should be automatically controlled to compensate for the varying drag of the spool itself.

Whatever means are employed for adjusting the tension, the value of the latter may be ascertained by a spring scale, if desired. A good rule-of-thumb is to adjust or increase the tension until you can feel the wire stretch slightly, and then release it until there is no apparent stretch. This will give approximately the correct tension. If the tension device of the winding ma-

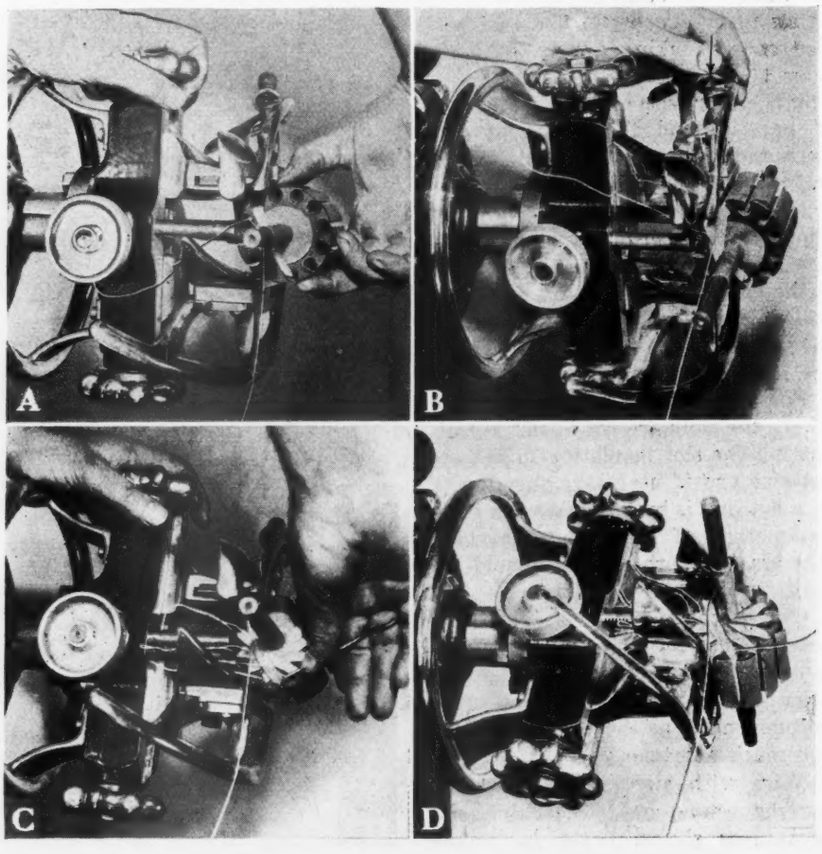


Fig. 2. After each coil is wound on, the core must be turned and the leads brought out.

In *A* the jaws of the machine have been released and the core turned one slot to the left. Most small, bipolar armatures are wound in this way. When the leads are formed by hand the core may be rotated the other way, if desired. *B* shows how the leads may be twisted by rolling a small handle between the thumb and forefinger. When the leads are short or the wire coarse, twisting is neither necessary nor desirable. *C*, a little hook may be used to advantage in pulling the leads out. The first end should be pulled to the right and the other leads kept to the left, as shown in *D*.

chine is not automatic, it will be necessary to give the wire considerably less tension and then make up the difference by hand, or by pounding the coils, which is objectionable.

Old hand winders give the wire that lies on the surface of an armature a negative curve or "set," in order to make it lie down snugly at the center of the core. If this is not done, the wire will stick up, or belly outward. This negative curve or set is imparted to the wire in the Chapman machine by passing the wire under and around a roller which is small enough to give the necessary curve and is mounted on a stiff spring, to aid in taking up the irregularities in the pull on the wire. The wings and the curves of the jaws have been proportioned to preserve this curve or set in the wire, so that it will lie down tight in the bottom of the slot. This is accomplished by shaping the guides so that they do not touch the part of the wire that goes into the slots.

Coming back to the winding operations, after the wire has been fed through the tension device, snub it by giving it a turn around the snubbing pin, as in Fig. 1 *C*. The excess wire may then be broken off by giving it a jerk, which will make the main portion hold against the winding tension.

The exact number of turns required may then be wound on. If there is more than one coil per slot, disengage the first lead from the pin and wind the second coil, as shown in Fig. 1 *D*.

After the lead is disengaged index or turn the core one slot to the left, Fig. 2 *A*. Ninety per cent of the bipolar armatures made in this country are wound in this manner and will turn in the right direction when assembled in their fields. The other 10 per cent should have the field connections or brush leads reversed. If the leads are formed by hand the cores may, of course, be rotated the other way.

If the leads are long and the wire is fine twisting is sometimes desirable. In the Chapman machine this may be done by rolling the handle under the thumb, as in Fig. 2 *B*. If the leads are short or the wire is coarse, twisting is unnecessary, or even detrimental. A very good method of securing the lead wire in the slot is to advance the winding wire into the empty slot before indexing, or turning the core.

When you are ready to finish filling the first slot, watch out for the leads. The first end should be pulled to the right. This may be done with the fingers or with a little hook, which is faster. The method of using a hook is shown in Fig. 2 *C*. The other leads should be kept to the left, as in Fig. 2 *D*. Another way to get the first and succeeding leads out is to remove the core from the machine, when it is released for turning. Pull the lead to the right, with the left hand, and replace. This requires only one motion of each hand and may be found even better than the use of the hook. By pulling the first end out at this time it will meet the last one at the finish and close up perfectly.

The procedure for winding the other coils is the same as outlined above, and should be repeated until all of the slots are full. When the last coil is in, cut the wire and twist the final end with the first end. If the first end was pulled out at the proper point, as explained above, they will match up perfectly.

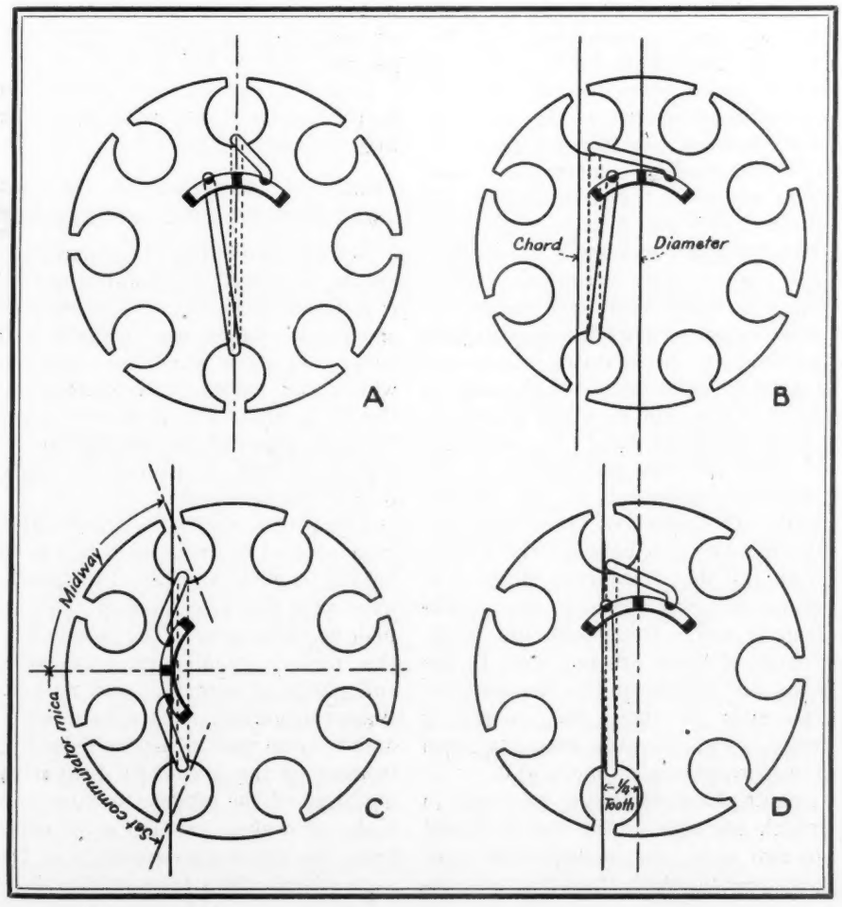
One point which it may be well to mention in connection with winding coils is that you should not make splices in a coil. If necessary unwind until the two ends come out at a lead.

After the rewound core is removed from the machine it will be necessary to fasten the wire in the slots. In the case of any armatures which have been wound with small wire, this may be done by tucking the ends of the slot insulation under the teeth, or by driving pegs in on top of the coils.

After an armature is wound the next step is to connect the leads to

Fig. 3. Diametrical or chord windings are used on small, bipolar armatures.

A shows the diametrical winding, in which the two sides of the coils are placed in slots located on a diameter or line passing through the center of the core, connected straight out, for brushes between the poles. A chord winding is shown in *B*. It will be noticed that the two sides of the coils lie in slots which are on a chord, or line parallel to the diameter of the core. The winding in *B* is shown connected straight out, when there is an even number of teeth in the core. The coil is displaced one tooth off the diameter, while the mica between the segments to which the coil is connected is displaced one-half tooth. *C* shows a chord winding connected for 90-deg. lead. A chord winding connected straight out when there is an odd number of teeth in the core, is shown in *D*. In this case the coil is displaced one-half tooth off the diameter, while the mica between the segments to which the coil connects is displaced one-fourth of a tooth.



the commutator. Inasmuch as this is an operation in which mistakes easily can be, and oftentimes are, made, it may be worth while to cover the ground in some detail.

How Leads Should Be Connected to Commutator

When connecting the leads to the commutator be very careful that no pulling tension is put on the leads, either by drawing them tight and soldering them, or by subsequent hooding or banding. If they are soldered under tension they will break off at the commutator after a few hours' or days' run, without any apparent cause. When soldering very fine wires I recommend the use of rosin as a flux; this may be dissolved in alcohol and is non-corrosive.

On the bipolar armatures there are two general types of windings, commonly known as diametrical and chord. In the former type of winding the two sides of the coils are placed in slots located on any line passing through the center of the core and through the center of the slots. A diametrical winding is illustrated in Fig. 3 *A*.

If the commutator is connected up without lead, connecting this type of winding is very simple, as it is only necessary to remember that *the mica between any two segments corresponds to the center of the coil that is connected between the two segments.* In other words, for a straight-out winding, the mica should be directly in line with the average center of the slot. The term "average center of the slot" is used because in skewed armatures the slot at the end of the core is not the average center. The mica should, in this case, be set in line with the center of the slot at the center of the core. If the commutator has a lead, that is, if the brushes are not placed between the pole tips, the procedure must be modified by moving the commutator the amount of this lead, using the points mentioned as a measuring point. This will, of course, place the commutator mica for 90-deg. leads directly in the middle of the coil.

The chord or second type of winding is the prevalent type, or at least very common, on small armatures. In this winding the two sides of the coils lie in two slots which are not on a diameter, but on a chord, that is, a line passing through the center of the two slots in which a coil is placed, but not passing through the center of the armature. A winding of this type is shown in Fig. 3 *B*. In this case, the above rule does not apply. The reader should remember that a chord-wound coil will behave, so far as commutation is concerned, just the same as though it were on a diameter which is parallel to the chord on which the coil is wound.

It follows, then, that the mica corresponding to the coil in question must not be placed opposite to the average center of the slots in chord-wound armatures, but on a diameter paralleling that chord. In other words, as the ordinary chord winding is one tooth off the diameter, the mica will have to be placed one-half tooth away from the slot which holds the coil, for a straight-out connection. Fig. 3 *B* shows a straight-out connection, the brushes being placed between the poles, for a chord winding when there is an even number of teeth in the core. For a 90-deg. lead, the mica will be placed directly opposite the middle of the coil, as in Fig. 3 *C*.

If there is an odd number of teeth in an armature, and the chord is only one-half tooth off the diameter, the commutator mica will be placed only one-fourth tooth away from the coil, and so on, as shown in Fig. 3 *D*. An easy rule to remember is: *The mica of the commutator should be moved away from its coil one-half of the displacement of the coil from a diametrical position.*

The preceding explanations have been made on the assumption that there is only one section of the commutator and one section of winding per slot in the armature. When there is more than one section of winding per slot in the armature, the point of the commutator which corresponds to the middle of the coils in a slot is the point to which the measuring should be done. For example, if there are two sections, it is the segment connected to the middle lead. If there are three sections, the middle mica between the middle leads is the measuring point. If there are four sections, the middle lead is again the measuring point. Again, if there are two slots in the core per section of the commutator, the mica is again the measuring point. In all cases measure from the average center of the slot.

Split chord windings, windings in which one side of the coil is placed in two slots, are connected straight out; that is, with the mica opposite the average center of the slot which holds the full half of the coil. If the commutator has a lead, measure the angle from the point specified. This type of winding ordinarily has little in its favor and should be avoided if possible.

If these simple rules are mastered they will solve the problem of connecting any type of armature, including freak types, that I have ever heard of. These rules apply regardless of whether the commutator has many or few sections.

If the leads are incorrectly connected trouble will show up principally in the form of sparking at the brushes and irregularity in the torque of the armature, from tooth to tooth. The armature will tend to hang or stick at every tooth. The torque of the motor will be less than it should and, if the lead is 90 deg. off the motor will not pull at all. In any case the current consumption will be high and the efficiency low. If the lead is backward, that is, if the neutral is carried back under the brushes, the motor may flash over.

In the case of a shunt- or compound-wound motor the speed will, or may, increase and the motor may try to run away. A series motor will run at reduced speed, when loaded, and the armature and fields will get hot.

The only remedy is to check the lead connections and make sure that they are correct.

Thorough Impregnation in Varnish Necessary for Good Service

Before varnishing an armature it should be tested for balance and if it is found to be out, the heavy side should be placed up to drain and bake. In this way the varnish, which will naturally be heavier on the light side, will tend to correct the unbalance. After baking the armature should, of course, be again tested and balanced.

Armatures should be thoroughly impregnated by immersion in a good baking varnish, and baked in accordance with the directions of the varnish manufacturer. The reason why the modern small armature, with full potential across it and no auxiliary insulation between coils, stands up so well in service is largely because of the wonderful insulating qualities of the modern baking varnish. However, varnish must penetrate the armature completely or the

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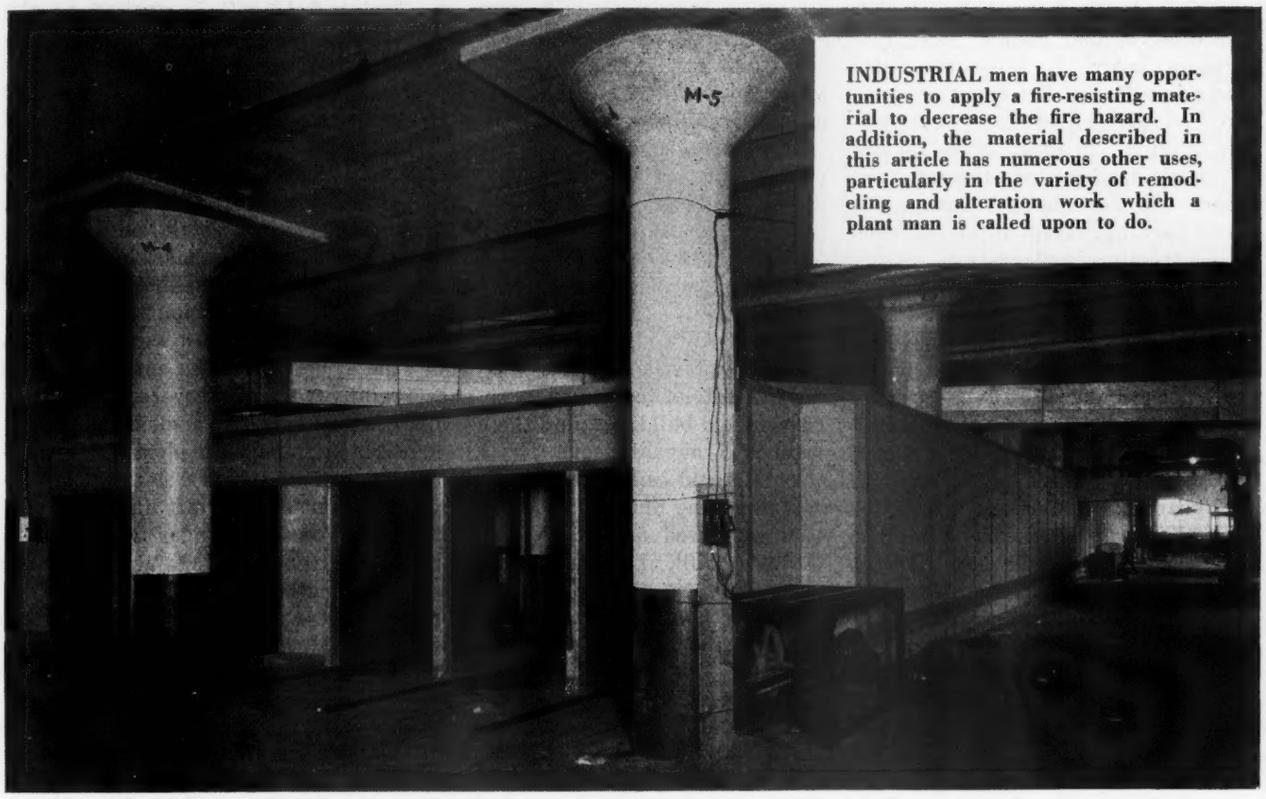


INDUSTRIAL men have many opportunities to apply a fire-resisting material to decrease the fire hazard. In addition, the material described in this article has numerous other uses, particularly in the variety of remodeling and alteration work which a plant man is called upon to do.

Non-combustible wallboard, built up on wooden studding is used to line and cover this body kiln in a St. Louis, Mo., automobile plant.

Some of the Many Uses of

Fire-Resisting Wallboard In Industrial Plants

For Protecting Mill or Frame Construction, for Altering Old Plants to Make Them More Attractive and Serviceable, for Constructing Kilns and Storerooms, and in Other Applications

By H. E. JEDDY
Engineer, Fireproofing Dept., United States Gypsum Co., Chicago, Ill.

PLANT alterations, change of production methods or the reduction of fire hazard often require extensive rearrangement of industrial buildings. Also, in many old plants there are unsightly walls or ceilings which it is sometimes difficult to make presentable. Frequently the production problem is such that clear, smooth walls are almost necessary.

One of the common and simple methods of making such alterations is by means of wallboard, as will be described here, together with other industrial applications of this material. For general industrial purposes, it is usually advisable to use one of the wallboards made of fire-resisting material.

This material is made of non-combustible gypsum, a rock product, to which is added some wood fiber for binding purposes. Wallboard comes in sheets, ⅜ in. thick and either 32 in. or 48 in. wide. Standard sheets may be obtained in lengths of 6, 7, 8, 9 or 10 ft. It is covered with a heavy fiber material; its edges are square and the fiber surfacing is folded back into the gypsum so as to prevent fraying and increase the strength of the edges. The board can, therefore, be nailed without danger of the edges being broken if ordinary care is used. It is not necessary to drill and bolt wallboard unless it is to be fastened to iron or steel shapes. This material may be nailed as easily as wood lumber and cement-coated nails are customarily employed.

Carpenters find that wallboard is much more easily worked than lumber and also more quickly applied, as it comes in large sheets which can be sawed to fit as easily as lumber. Also, the large area in each sheet makes it easy to cover considerable surface at a time. The wood fiber contained in the wallboard helps to make it sufficiently flexible so that the sheets may be adapted to slight curves where the nature of the construction requires it. Even though the sheets are quite large they are light enough so that they may be easily handled.

Some of the characteristics which make this material adaptable to industrial plants are that it presents a surface which may be easily finished, it may be applied to either walls or ceilings, and does not disintegrate so that particles may drop, such as may happen with plastering, and fall into the product or machines. This is of particular im-

portance in food products, textile and other similar plants. Also, this gypsum board is non-combustible and has sufficient fire-resisting qualities so that an ordinary fire does not affect it. In addition the amount of heat transmitted through the board will not char or damage the wood backing, except in an extremely destructive conflagration. Other characteristics which make this material of considerable value to industrial men are, the ease with which it takes a finish, a surface which does not crumble and the fact that it is not affected by ordinary atmospheric conditions.

One of the many advantages of wallboard in industrial construction is that it provides a smooth,uniform surface which can be covered with any kind of paint, calcimine or similar protective or decorative covering. If wallboard is to be painted, a priming coat of half varnish and half paint is recommended. This gives a surface which will take any finish. These decorative possibilities are of considerable importance in industrial plants, and this characteristic of wallboard makes it available wherever a high degree of light diffusion is required or where a tight, non-crumbling wall or ceiling is desired. Hence, one of the most common uses is in finishing over old industrial plants. For example, in case it is desired to devote a portion of the plant to office purposes, the brick walls are generally covered over with plaster or some form of wallboard. Wallboard may be applied by the plant carpenter; so it is not necessary to lath up the surface and get outside plasterers to finish the job.

In applying wallboard to brick or masonry walls it is recommended that 2-in. by 2-in. furring strips be set on the standard 16-in. spacing; 1-in. by 2-in. furring may be used, but this does not give as substantial a support as the former. Wallboard is nailed directly to the furring strips. Headers are placed at the top and bottom so that all edges are supported. It is, of course, necessary that the furring be substantially attached to the wall and evenly lined up.

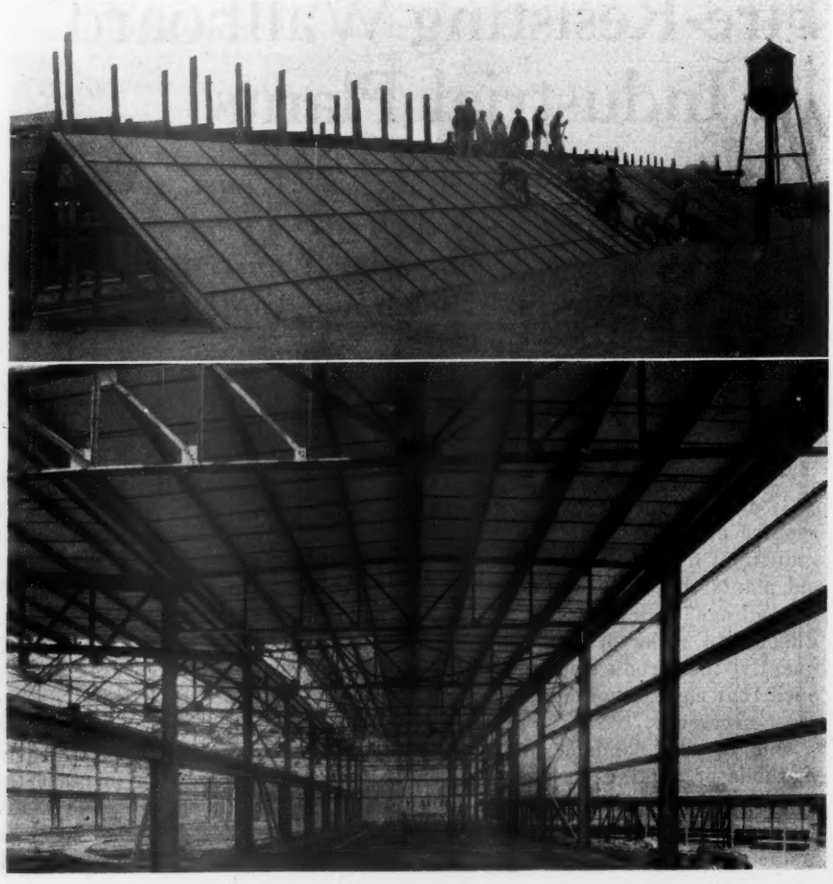
In covering up chimneys, columns or other projecting corners, it is not always necessary to fur against the wall. It is usually better to build a separate framework of 2-in. by 4-in. plank, which is not anchored to the chimney.

Frequently plants engaged in producing textile products, particularly if extensions require that they remodel old buildings, find the use of wallboard advantageous for lining the walls and ceilings. Some of the accompanying illustrations show how this was used at the Taubel-Scott Hosiery Mill, Lenoir City, Tenn. Here 55,000 sq. ft. of Sheetrock were used in the remodeling of an old brick factory. Inasmuch as in this case the joists were not sized it was necessary that the ceiling be cross-furred and the wallboard nailed to the furring. In doing this, all electric wires and sprinklers were lowered and the boards were installed without interruption to operations.

Where it is desired to make a joint between the boards, which is not noticeable, a special plaster, called "joint finisher," is applied to the crack. If care is exercised in finishing over these joints they will hardly show when painted. Sometimes panel molding is placed across these cracks to give a paneled effect. In this hosiery plant, however, the joints between the boards were left unfinished just as the edges of the sheets fitted together, since appearance was not a factor deserving of extreme consideration.

The wall surfaces were treated in the same way. The entire wall and ceiling were then covered with a mill white paint. This made a clean, well-lighted room with plenty of reflecting surface which was not only sanitary but did not sift dust, as would have been the danger with the former wall and ceiling surfaces. Such construction makes a room an attractive work place; there is a pronounced contrast between this and rough brick walls and unfinished ceilings. This is particularly advantageous in plants where women workers are generally employed.

In this same hosiery mill, Sheetrock was also used in the construction of the lower portions of the various bins in the storeroom, as shown in an accompanying illustration. This gives not only a clean



Exterior and interior views of a special fireproof roof construction at the Essington, Pa., plant of the Westinghouse Electric and Mfg. Co.

Here a gypsum wallboard is used as the bottom of the mold for casting the roof sections which are reinforced with steel fabric and a special Pyrofill mix of the desired thickness is poured into this mold. This material binds with the wallboard, and hardens into a monolithic construction which is covered with a water-proofing preparation. The wallboard forms a smooth and also fireproof ceiling.

and sanitary construction, but it is also practically fireproof. The ceiling and walls of this room were finished off with wallboard the same as in the rest of the factory.

Partitions extending part way or entirely to the ceiling may also be made in this same way from wallboard. As the industrial man has the choice of sheets from 6 to 10 ft. long, it is usually possible to get a length which is equal to the partition height without extra cutting, and so save considerable labor in its erection.

The foregoing applications by no means cover the entire list of uses of this material for industrial reconstruction. Garages, for example, are frequently lined with it, both for the heat insulating value and also on account of the practically fireproof construction which it gives. Other uses are in locker rooms, rest rooms, lunch roooms and practically any other place which it is desired to finish off or enclose. The construction is not only economical, but easily applied.

In addition to the use of this material for refinishing on the inside of industrial buildings, one of the earliest instances of the use of this material for the reconstruction and protection of industrial buildings was in the Boston & Albany R. R. freight warehouse and in the Cunard Line pier freight house at East Boston, Mass. In these, the fire hazard presented by the wood construction was a matter of much concern. After extensive fire tests the entire interior wood construction of these large and highly combustible buildings was protected with gypsum plaster board. This material was quite similar to the present gypsum wallboard, except that it was thicker and the panels were of different size.

All of the large wooden roof trusses in these warehouses were fire-protected by two layers of ¼-in. board with the joints broken in both directions. The rest of the construction was covered with ⅜-in. plaster board, sawed to fit and applied so as to follow the contour of the construction and avoid concealed air spaces. Wooden columns, girders, beams and ceilings were treated in the same way. Also, a number of non-bearing fire-resisting partitions, which consisted of wooden supports covered on both sides with the gypsum plaster board, were constructed to divide the buildings into fire sections.

When this installation was inspected recently, some 23 years after its erection, it was found to be in good condition except for a few places where excessive leakage through the roof had caused damage to some of the panels. However, no distintegration due to the humid atmosphere along the water front was observed. A similar construction has been used in a number of other warehouses since.

Because of its fireproofing qualities and ease of construction wallboard has been used for the construction of dry kilns in numerous industries. Here the primary requirements are incombustibility, heat insulation, ability to withstand humidity, accessibility, economy, and ease and rapidity of installation. Many of the large motor car manufacturing companies have used this material in the construction of their drying kilns for varnished work. Altogether from 8,000,000 to 10,000,000 sq. ft. have been used for this purpose.

Three such kilns, one of which is shown in an accompanying illustration, installed in 1919 in a truck factory in Buffalo, N. Y., may be considered as typical of the general construction used. These kilns cover a ground area 40 ft. by 60 ft. and are 8 ft. 6 in. high. In the construction of these, a frame of 2-in. by 4-in. lumber was erected with studding spaced 32 in. on centers, with a header every 48 in. Wallboard was

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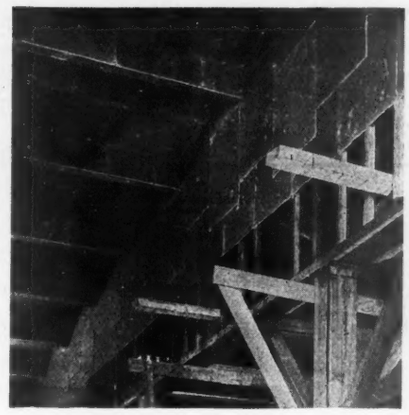
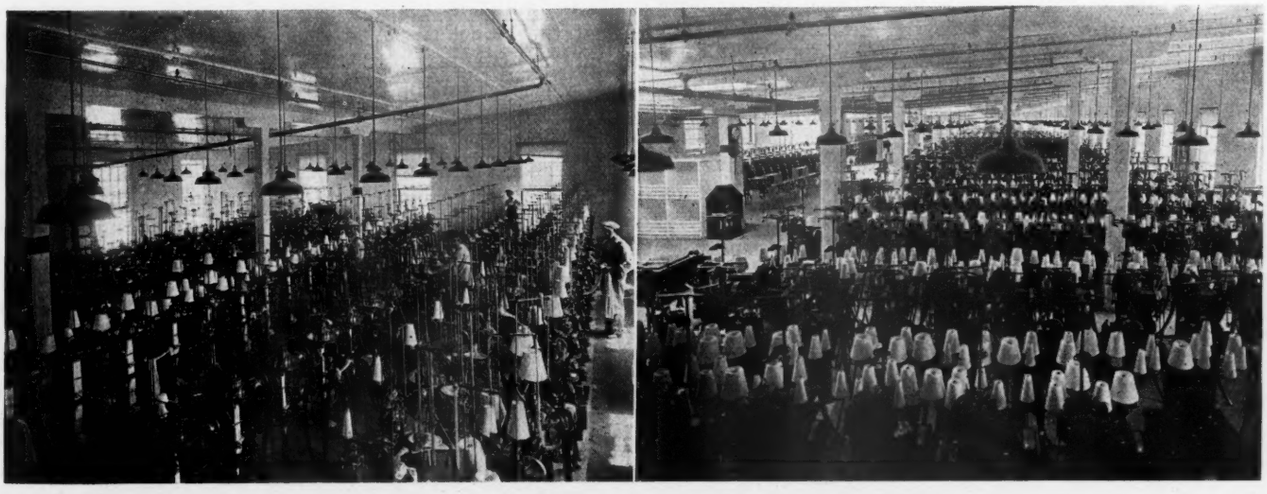


Gypsum board is used here for beam protection as well as for sheathing on ceiling and partitions.

This was applied to the freight warehouse of the Boston & Albany R. R. to reduce the fire hazard in an open frame construction. Inspection after 23 yr. of service showed that, except in a few spots where water had leaked in through the roof, the material was as good as ever. However, the material is damaged by water only after long and repeated exposure to alternately wet and dry conditions.

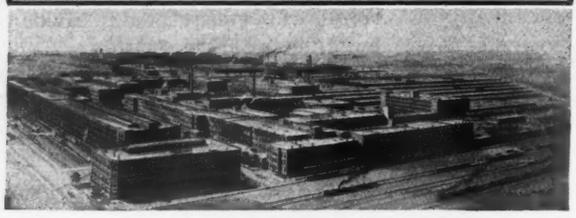
Two views of a remodeled interior in a hosiery mill.

The walls in this plant were rough brick and the ceiling joists were not covered when the Taubel-Scott Hosiery Mill, Lenoir City, Tenn., decided to remodel the plant. Electric wires and sprinklers were lowered and the wallboard installed on the ceiling without interruption to operation. Both wall and ceiling surfaces were then painted with a mill white paint, which makes them much more attractive and sanitary, and also prevents dust or grit from sifting through the ceiling or breaking loose from the walls and so getting into the product or machines.



INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
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Chicago, May, 1925

The Wrong Way To Decrease Cost Of Maintenance

ONE of the first principles of good management, as well as effective cost accounting, is to charge all expenses to the individuals, products or departments which are responsible for them and would be most affected by an increase or decrease in these expenses. In this way those individuals responsible for the expenses have a more vital interest in keeping them within reasonable bounds. This is as true of the cost of maintenance as of any other industrial expenses. However, not all plant managers consider fully this important point.

Recently a practical man, who had been supervising the maintenance work in a large plant, pointed out a good example of the futility of expecting to get results when this principle of managerial control is ignored. In this plant all maintenance costs, for both material and labor, were charged simply against "Maintenance," probably to eliminate the bookkeeping cost of apportioning these expenses to the various departments. As a result the maintenance engineer was the only man interested in reducing this cost. The only way he could do this was to try to economize in time or material; in other words, he had to skimp on the repair jobs which, in turn, tended to increase the frequency of the repairs.

Since the foremen had no charge against their departments they were inclined to neglect the equipment and run it until it failed. They also resented any interference as long as the motors and drives would operate, even though a few minutes' attention would have made a worthwhile saving in the ultimate cost. The management, in turn, took the maintenance engineer to task for the heavy expenses charged to his department. Caught thus in the cross-fire of the foremen and of the management, the maintenance engineer finally gave up and a new man came in to fight the same battle, that several of his predecessors had lost.

Men who think that they can lump maintenance costs in a pile and expect to save by merely looking at and complaining about its size are only "kidding" themselves. The only way to keep maintenance costs down is to attack them at the source and make each department responsible for its own costs. Then, if the repair work is skimped the foremen have a perfect right to complain loudly; however, if the foremen neglect the equipment, the maintenance engineer has an opportunity to defend himself. Luckily, such conditions as described are in the rapidly-decreasing minority.

When Did You Test Your Transformer Oil?

BECAUSE it does not move and the only sign of activity is a pump, we are prone to think that a transformer can run just a little longer without attention. Too often this "just a little longer" stretches out into months and years, sometimes with no apparent bad effects; and then again a very disastrous failure occurs which wipes out all of the time and labor thought to have been saved by not doing the required maintenance at regular intervals.

A plant recently visited illustrates a case where the trouble was caught in time. The transformers supplying vital feeders in the plant had not had their oil tested for several years. Samples were drawn and sent to a testing laboratory in another city. The tests showed the oil to be low in dielectric strength, so the oil in each transformer was run through a purifier. A year later the oil was again tested and found to break down at 15,000 volts across a 100-mil spark gap, when it should have broken down at 22,000 volts across such a gap. This time the oil was filtered until successive tests made on the job, showed that the samples of oil taken from each transformer would pass the required test.

Atmospheric conditions, nature of load cycle, and many other conditions have a bearing on when the oil will break down in the transformer during normal operation. Be on the safe side by making regular tests of the oil in your plant, and purifying the oil promptly when tests indicate that it is required.

Don't Misuse Your Fuses

THOSE responsible for continuous operation of motors and other electrical equipment in industrial works, know by experience just how much it costs to have a fuse blow. The cost of a renewal link is insignificant. The expense of having someone take out the blown fuse and replace it with a good one is only a little more. The real expense is the delay to production and the possibility of spoiled material that is in process.

A fuse is a safety valve and when rightly used it is a good friend. When a fuse blows, it is ridiculous to think that something is the matter with the fuse. Either the fuse was too small or the load carried was more than should be carried by the apparatus that the fuse is put there to protect.

An investigation made by Charles R. Hepner, chief electrician of the Willard Storage Battery Company, revealed that their so-called fuse troubles were due to their own carelessness and he is perfectly frank in calling it carelessness. Mr. Hepner found that the trouble could be attributed to six causes, none of which was a fault of the fuse. On page 228 of this issue,

Mr. Hepner gives some very interesting data on the results of his investigation, together with the remedies that he applied with remarkable success in the reduction of motor outages. On page 40 of the January issue, A. W. Oppman described a fuse color scheme that he has used to prevent improper use of fuses.

Application of the methods and facts presented in these two articles will cut your fuse renewal costs and, what is more important, will reduce your power service delays.

If You Do Your Work Well Enough You Won't Have to Do It

PROBABLY everyone has wondered at times why promotion or salary increases did not come faster. In any particular case there may be a number of reasons why substantial advancement is slow in coming, or does not come at all. One of the most common reasons, however, is lack of that pride of craftsmanship which is satisfied only with the very best job that can be done. With that pride usually goes a willingness to undertake any task within reason and do it to the best of one's ability. On this point one of our readers recently made the following interesting and significant statement:

> I have been through the mechanical machine shop and electrical maintenance and have taken considerable pride in handling any job which came along, whether I had ever seen it before or not, and doing it successfully; but I suppose that is why I am not doing it now.

The mere retention of a place on the payroll is not necessarily an evidence of real success—the kind that leads to foremanships and higher positions. Very mediocre ability can and oftentimes does find a more or less permanent place in industry, as well as in other lines. Nevertheless, the men who hold positions of responsibility in the industrial world have, in the great majority of cases, attained these positions only after a long training period in which conscientious and unremitting efforts were made to perform every job in a thoroughly workmanlike manner.

Taking it by and large, when a man learns how to do his work expertly and efficiently, he does not have to do that kind of work very long—he will be given the job of showing others how to do it.

What Do You Do With Old Equipment?

DISPOSAL of old equipment is one of those things that are frequently left to take care of themselves. Often the equipment is considered too good to be junked and there is a vague idea that it may some day come in handy as a spare, and is, therefore, worth keeping. Usually the result is that the equipment is shoved off in some out-of-the-way place. By the time that a use for it has arisen, it has been forgotten.

A case in point came up recently in a small plant that generates its own power. The direct-current generator in use was badly overloaded, by reason of additions to the plant. One day the inevitable happened—the commutator became so hot that the solder melted and the machine was put out of commission.

The service man who was called in to make the repairs recommended that a larger generator be purchased. The management would not consent to this and asked that some other solution be worked out—a case of making bricks without either straw or clay.

While passing through the boiler room the service man noticed an old alternator with a belted exciter, the whole outfit so covered with coal and dirt that it was hardly recognizable. He was told that it had been taken out of service five or six years previously, and forgotten. After some of the dirt had been scraped off he found that the rating of the exciter was large enough to enable it to carry the excess load on the main generator.

Several hours of hard work were required to put the exciter in running condition. After that it was a simple matter to belt it to the engine which drove the main generator. The problem was thus solved at trifling expense.

This incident has, with some variations, been duplicated in many plants, although the ending is sometimes different; a new piece of equipment has been purchased and the discovery later made that a discarded but still serviceable piece of equipment was available.

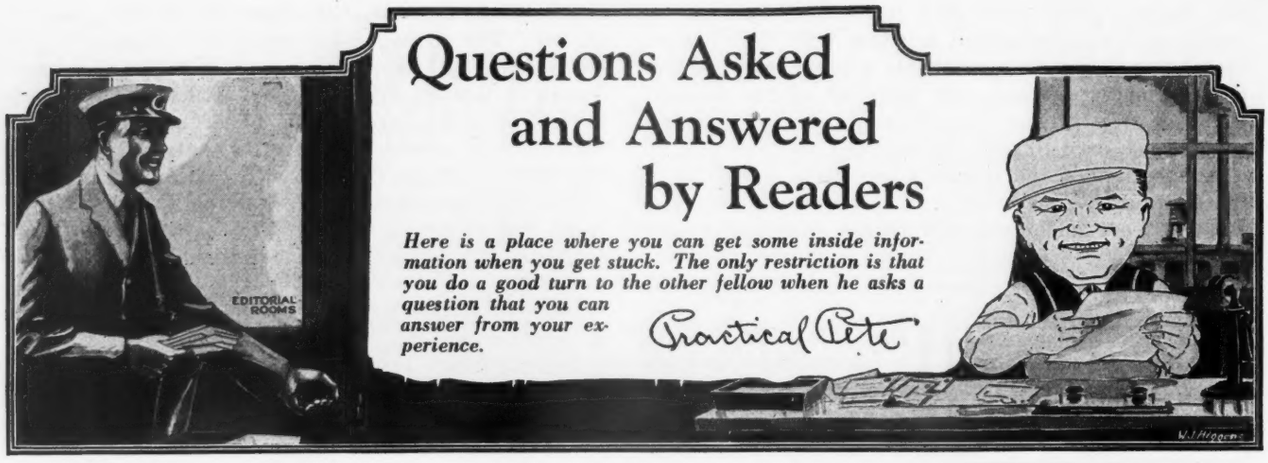
When equipment is taken out of service there are just two things to do with it: If it is worth keeping in reserve, put it in good condition and store it where it will be clean and not likely to be damaged. Further, a complete record should be taken and filed for reference. If the equipment is of such type or rating that it is not likely to be used again—sell or junk it. The sale or junk value may not be high, but it is far better to have this value in the form of money than in the form of useless equipment which serves merely to make an untidy-looking plant.

Poor Housekeeping Causes Most Plant Fires

FIRE losses during 1924 were exceptionally heavy since, even though there were no unusually large conflagrations, the total number of fires, according to the *Industrial Fire Chief*, probably exceeded that of any other year. Of these fires an estimate obtained from a careful study of fire records and confirmed by fire insurance executives, shows that probably 65 per cent were due to easily preventable causes. Inspection reports, by the same authorities, indicate that industrial as well as commercial concerns have skimped on expenditures for upkeep and repairs.

The natural effect of such neglect is a psychological reaction of the workers; a reaction of carelessness which is in keeping with the carelessness and neglect of the plant and premises. All of this tends toward careless housekeeping: one of the most common underlying causes of fires. Where fires are not directly traceable to poor housekeeping it is usually easy to show how they originated from carelessness imbued in men through prolonged association with slovenly surroundings.

Whether a plant is over-busy or just keeping going is no reason for neglecting maintenance and upkeep, nor plant housekeeping. If the plant is busy it has need for everything to be well done; if the plant is barely operating the wide-awake manager will find opportunity to squeeze in the necessary time to do this work at practically no additional outlay.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Comparative Advantages of Compensators and Primary-Resistance Starters—I shall appreciate it if some of our readers will give me their experience or opinions on the comparative advantages and disadvantages of compensators and primary-resistance starters for starting induction motors.
Cleveland, Ohio. F. G. H.

* * * *

Rewinding 110-Volt Generator for 6 Volts—I have a 110-volt, 0.25-kw., 2,000-r.p.m., shunt-wound generator and should like to know if it can be reconnected or rewound to give six or eight volts, for charging storage batteries. If so, will some reader please give me some information on the size of wire to use, number of turns and so on?
Allentown, Pa. A. H. S.

* * * *

Special Skid for Moving Machinery—We are planning an extensive rearrangement of machines such as lathes, screw machines and the like in one of our departments. I wonder if any of our readers have had experience in making a special skid or platform for holding such machine tools during the moving operation. I think that some such scheme as this would be quicker than trying to build a skid for each machine that is moved, but am hazy as to the best way of handling this kind of a job.
Milwaukee, Wis. G. F. H.

* * * *

How Does This Motor Start?—I have a motor made by the General Electric Company that has the following nameplate data: Ser. No. 79,281, type IS, class 4, form A, 60 cycles, 1,800 r.p.m., ½ hp., 110 volts. The nameplate does not say whether the motor is single phase, but as there are only two leads coming out of the machine, I think that it must be a single-phase motor. It has a solid rotor, no starting switch, and no split winding for starting the motor. The winding in the stator is similar to a chain winding. The armature has 36 slots, two of which are empty. The empty slots are spaced seven slots apart. Can some reader tell me how this motor is started from a single-phase power supply?
Oakland, Cal. N. N.

* * * *

Operating Motors in Parallel on Bridge Motion of Crane—Two series motors are used to drive the bridge motion of one of our cranes. Each motor drives one set of track wheels, so that the two motors are practically operating in parallel. They are controlled by two contactor panels operated from one master switch. With this combination the armature burnouts were so frequent that it was decided to connect the armatures of the two motors in series and the fields in parallel. As we still had burnouts it was decided to connect the armatures and fields all in series. This has eliminated a great deal of the trouble, but it reduces the speed of the bridge.

I would like to know what is the cause of the trouble that I have been experiencing. Can some reader suggest a method of connection that will eliminate the trouble from burnouts and at the same time give normal speed on the motors?
Indiana Harbor, Ind. A. R. D.

* * * *

Trolley Wire Supports for Monorail Crane—I have a monorail crane running on an I-beam, which has to travel around two rather sharp bends, and wish that someone would give me his experience as to the best way of installing and supporting the two trolley wires that feed this crane. How should I support the wires where they go around the bends?
Barre, Vt. C. G.

* * * *

Does Change in Transformer Connections Affect Rated Capacity?—I have three 100-kva., single-phase, 2,200-110-volt transformers, which I intend to connect in a bank to deliver three-phase power at 110 volts. If a delta-delta connection is used to connect the bank, what power capacity can I get from the transformers? Will I get the same power capacity from a star-star connection? I shall appreciate any information that readers can give me on this question.
Telluride, Colo. T. H. C.

* * * *

How Much Time Is Required to Wind These Stators?—I would like to know how much time should be required to wind semi-closed slot stators for 40-deg. and 50-deg., General Electric motors and also for the type CS motors made by the Westinghouse Electric & Mfg. Company. By this I mean the time required for insulating the cells, inserting the coils, putting in the wedges, and connecting. Will some reader give me what he thinks is a reasonable time for winding stators of the kind mentioned, having 36, 48, and 72 coils, and having horsepower ratings from one to ten?
Springfield, Mass. H. P. B.

* * * *

Why Does This Motor Run Slow?—We have two wound-rotor motors, each rated at 325 hp., 2,300 volts, 60 cycles, and 1,185 r.p.m. at full load. Both of these motors are running about 30 r.p.m. below their rated speed. The frequency of the power supply is normal, for the generators are running at their correct speed of 3,600 r.p.m. About nine years ago the ventilating fan blades were removed from the rotors of the motors and consequently during the summer the windings become quite hot. When the motors are running the pointer of the power factor meter swings continuously. The pumps that are driven by these motors have recently been overhauled, but there was no increase in the speed of the motor. Since the pumps are running at less than rated speed, the motors do not draw rated full-load current. Can some reader tell me what causes these motors to run at less than rated speed and how I should go about correcting the trouble?
Medicine Hat, Alta., Can. E. A. S.

Answers Received To Questions Asked

Supporting Lineshafting on Concrete Pillars—I have to support several long runs of lineshafting on concrete pillars and should like to know (1) if this is considered good practice. (2) Will it be necessary to use adjustable pillow blocks, or will the solid type be satisfactory? (3) Is there enough danger of the pillars settling or getting out of line to make it necessary to brace these in any way?
Brooklyn, N. Y. C. R. P.

Answering C. R. P. in the February issue, the ordinary place for supporting shafting in mill buildings is from the ceiling, but there is nothing wrong in supporting it on columns provided the columns themselves have been properly designed for this duty. Columns supporting lineshafting would have to carry not only the dead load from the floors above but also be able to stand the continued vibration of the rotating shaft and the cross-bending resulting from the pull of the belting. Without a knowledge of the detailed design of the columns, horsepower to be transmitted, spacing of the columns, dead load on each column and number, location, direction and size of the various belts, it would be impossible to give to this question an answer which would be correct in any particular case.

Assuming that this is a reinforced concrete building properly designed for factory or mill use and that the columns have been designed for the purpose stated, there would be no question about the propriety of mounting the shafting on the columns. With the same assumption, there would be no necessity of bracing the columns to prevent settling or movement out of line.

As to the necessity of using adjustable pillow blocks, this again is a matter which hinges on the design of the columns, their spacing, horsepower to be transmitted, lineshaft speed, and so on. If the shaft turns at a fairly low speed, and making the same assumptions as to proper design as above, a bearing similar to the Dodge rigid post bearing would ordinarily be considered satisfactory. With these, ample vertical adjustment is secured by means of elongated slots in the backplate or face. Horizontal adjustment can be obtained by the use of shims between the backplate and the face of the column. For higher speeds I believe that adjustable

pillow blocks should always be used.

This raises the question of anchoring the bearings to the column. Modern reinforced concrete construction for mills and factories often makes use of commercial fixtures such as are manufactured by the Midwest Steel and Supply Company for supporting shafting, piping and the like. Shapes have been developed which can be placed in the forms and concrete poured around them. Other shapes have also been developed for use in buildings already constructed. When the building is already constructed and no special provision has been made to support shafting, piping and so on from the walls or ceiling it will, in most cases, be necessary to drill holes in the concrete and set in some one of the many kinds of expansion anchors to support the machinery. In some columns this may be very difficult to do because of the reinforcing iron embedded in the concrete. In drilling for such anchors the reinforcing iron must not be cut, for its usefulness would thereby be lessened if not entirely destroyed. In the case of small- or medium-sized columns, wrought-iron straps may be placed entirely around the column and the bearings fastened thereto by bolts, thus avoiding the necessity of drilling the concrete and setting anchor bolts. This method could be used with larger columns also, but the chances of being able to place the anchors properly without striking the reinforcing iron are better than in the smaller columns; also the cost of material and labor for the straps would be proportionally greater than for the smaller columns.

Fort Worden, Wash. E. I. PEASE.

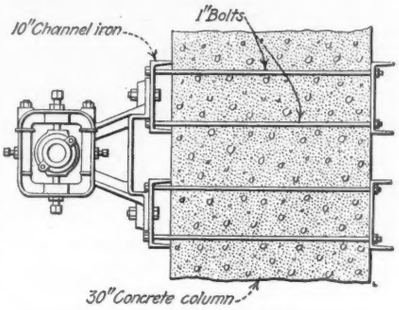
* * * *

Referring to C. R. P.'s inquiry in the February issue, it is common practice to support long runs of lineshafting on concrete pillars and this should give excellent results if the weight of the shaft and belt pull are not out of proportion to the size of the pillars. Most heavy lineshafts are supported in wedge-base, self-aligning pillow blocks on concrete piers installed especially for this purpose, but judging from the remark about bracing them, I judge C. R. P.'s pillars are building members, in which case they will probably be stiffer than any bracing that could conveniently be applied.

For supporting moderate-sized shafting—up to $3\frac{7}{16}$-in. or thereabouts—on rectangular concrete posts, we have found the arrangement shown in the illustration to be cheap, convenient to erect and very satisfactory in operation. The size of the channel iron must be proportioned to the size of the shafts and the width of the column, but for $3\frac{7}{16}$-in. shafts and a column width of 30-in., a 10-in. channel iron is about right. The channels are cut about 6 in. longer than the width of the post and drilled so as to bring the bolts close against the sides of the posts. Under the above conditions, use 1-in. bolts. Filling the space between the channels and the post with a heavy grout thoroughly packed in is important as it not only increases the bearing area and prevents the edges of the channel cutting into the post but materially stiffens the web where the hangers are bolted.

Adjustable bearings are essential, as it would be practically a hopeless and endless job to line up a long shaft by shimming out solid boxes and jacking them into line.

Settling or leaning of posts, buildings or any other form of structure is altogether a question of foundation, which must be of sufficient area not to exceed 2 tons pressure per sq. ft. on any part of the area, and less on loose, sandy soil when the structure is subject to vibration. The foundation must be carried down below the frost line and preferably should go down to solid soil.



Bracket hangers may be conveniently supported on channel irons bolted to concrete columns.

If this is impossible the solidest spot available must be chosen and the base area increased correspondingly. Settling is bound to occur if an attempt is made to build on recently filled-in soil. In such cases, driving piles to a firm bottom is the only way of getting a satisfactory job.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.
New Haven, Conn.

* * * *

In answer to C. R. P. in the February issue, it would be well to use an adjustable pillow block, if for nothing more than to take up wear on the shaft or in the bearings, as a multiplicity of sags will increase drive friction.

If there is any danger of the pillars settling, by all means use a pillow block which can be adjusted. However, as the pillars are concrete, there is not much chance of them settling.

Jamestown, N. Y. H. S. RICH.

* * * *

In reply to C. R. P. in the February issue, (1) I do not consider it good practice to support lineshafting on concrete pillars except when anchor bolts are provided for this purpose during the construction of the pillars.

Good results may, however, be obtained in some cases by drilling holes in pillars with a star drill for lag screws. Each hole should be made ⅜ in. larger at the entrance than the diameter of the lag screw to be used and gradually tapered out larger so that the bottom of the hole is ¾ in. larger than the screw. Then run the holes full of molten lead and drill them out the size of the lag screw, less the depth of the thread.

I think it is good practice to put a small quantity of oil or grease of some kind in each hole before pouring in the molten lead, as this will eliminate danger of explosion in case there is any dampness in the holes. In all horizontal holes cut a groove in the top side deep enough to afford a vent so that the hole will fill full at the bottom.

(2) It is advisable to use an adjustable bracket, sometimes called a post hanger. Pillow blocks may be used but undoubtedly they could only be properly lubricated by the use of grease cups.

(3) Settling of the pillars will depend largely upon their foundation and the weight that is applied upon the floors above, which they support.

Marietta, Ohio. E. L. WAY.

* * * *

Referring to C. R. P.'s question in the February issue, (1) local conditions and special requirements to be met govern to a great extent certain practices. Without definite information and specifications it is rather difficult to comment intelligently on this question. However, generally considering the problem, it can be done to agree with good practice.

(2) Adjustable pillow blocks have the advantage of comparatively easy adjustment for alignment by virtue of their design, although they are not absolutely necessary. The solid type can be used if mounted on shims for adjustment in one direction, and by using slotted or elongated mounting holes adjustment can be obtained in the other direction.

(3) The question of concrete pillars to support the shaft bearings involves a survey of the sub-soil conditions. Good, solid, dry earth or hardpan should form the basis on which to build the concrete pillars to assure no settling due to change in the sub-soil. For the foundations and pillars a concrete of 1-2-3 mix should be used. Use as little water as possible to obtain the final maximum strength from the concrete. If the torque on the shaft is at such an angle as to put a bending moment on the concrete pillar, use several reinforcing rods through the whole length.

Concrete that is well tamped and not too wet, settles only slightly during the period of its initial set which is about 45 min., depending upon climatic conditions. After the first set to the final set, which requires about six days, practically no shrinkage occurs. With the proper care in preparing the foundations, placing the forms, and mixing the concrete, no difficulty will be experienced in settling or shrinkage of the concrete pillars.

Milwaukee, Wis. E. H. LAABS.
Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,

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In the February issue, C. R. P. asks Practical Pete whether concrete pillars are good supports for lineshafting. He can rest assured that concrete is an eminently satisfactory material for this purpose. Where it has apparently proved otherwise, the trouble was not due to any inherent defect of concrete, but to the method of installation.

A frequent and unreasonable demand made on concrete is that it carry heavy and vibrating loads the day after it is

poured. While the high-alumina cement now to be had will give a concrete that attains a large part of its ultimate strength in a day or two, concrete made from the common cement must be permitted to set for a considerable time in order that it may become sufficiently strong.

There has been much discussion as to whether bearings or machinery should be set directly on the concrete base or on an interposed timber. Both methods of installation have proved satisfactory. The advantage of setting the equipment directly on the concrete is that the latter then becomes in effect an integral part of the machine and as such assists in absorbing vibration. Capping the concrete with timber enables one to readily fasten equipment with lag-screws when the hold-down bolts do not happen to be in the desired positions, but aside from this feature, the wood offers no real benefit and, as I shall show, may be a positive detriment.

Some years ago, among the power plant equipment in my charge was a toothed-roll crusher used to break mine-run coal to stoker size. This had a very light frame for the size of the rolls and the work required of it, and gave much trouble by moving about on the timber frame interposed between it and the concrete foundation. It had been necessary to place guides against the drive belt to keep it on the pulley, and the crusher running. Tightening the nuts on the foundation bolts availed little because the timber was oil-soaked; bolts passing through timber are not well adapted to taking bending and shearing stresses. We took out the timber, cut the threads on the foundation bolts down to the concrete, replaced the crusher, and its quiet running thereafter made us feel a bit ashamed.

On another occasion two bearings out of eight that carried a quill-shaft driving a number of grinding mills, gave trouble from apparent settling of the concrete piers. All of the bearings rested on 8-in. by 12-in. oak caps, the 8-in. dimension being vertical. While the bearings were provided with base plates that permitted lateral adjustment, they could not be adjusted vertically; so shims were used to line up the offending bearings. An examination showed that six of the oak caps were of the same thickness while the other two (those under the offending bearings) were ¼ in. less in thickness. The conclusion was that the six caps had been cut from dry timber while the other two had been cut from green or wet timber, and had shrunk in drying and disturbed the alignment of the shaft. This conclusion was strengthened by marks on the under side of these caps indicating that they had been chipped to the required thickness with an adz at the time of installation. The inference is obvious—when cutting timber for use in supporting machinery, be sure that it is dry.

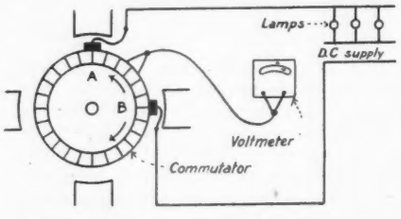
C. R. P.'s question does not indicate what his concrete "pillars" are. Pillars may be anything from piers to columns. His intention to use pillow blocks indicates that his shafts will rest on the tops of supports of some kind. If this is the case he will be compelled to use a concrete (or possibly brick) base anyway; so he may as well carry the concrete up to the pillow blocks, and any shimming that may have to be done in the future can as readily be done on concrete as on wood. Whether the pillars will require bracing depends on their height.

Los Angeles, Calif. C. O. SANDSTROM.

* * * *

Testing D.C. Armatures With Voltmeter—(1) Will some reader please tell me where to place the lampbank leads on the commutator when testing direct-current armatures with a voltmeter? For example, in the case of a four-pole armature should I touch the leads to the commutator on the quarter or on the half? Where should the leads be placed on a six-pole armature; or an eight-pole armature? (2) When testing a four-pole armature I touched the lampbank leads to the commutator on the quarter and got a good reading on the meter until I came to the next quarter of the commutator. Then the deflection was in the opposite direction. When I reversed the meter leads there was no reading on two bars of the quarter. Continuing ahead I got a good reading until the next quarter was reached. What did that indicate?
New York, N. Y. H. B.

Referring to H. B.'s question in the January issue, (1) for a four-pole, six-pole or eight-pole field the test current should be applied at two adjacent brush contact points as indicated in the diagram, and the bar-to-bar test made between the two contact points only. When this section has been tested, either revolve the armature or shift the two contact points, keeping the same spacing and again test between bars. This method is a desirable one since it approximates closely the actual current flow in the armature. In the diagram the flow of current is shown by arrows.



Application of voltmeter test to direct-current armature.

(2) Referring to the diagram, assume that the tester begins at *A* and tests towards *B;* it may be assumed that, as indicated, the flow of current through the winding is from *B* to *A*, as *B* is connected to the positive supply lead. Should the test be carried beyond *B* without changing point *B*, the current in the next portion of the winding will be flowing in the opposite direction and the voltmeter will show a reversed reading. If two positive and two negative contacts were made at one time at the quarter points, a continuous test could be made, reversing the meter leads after passing each brush or contact point.

A zero reading between two bars will generally indicate a short-circuited coil. The contacts should cover about the same area as a brush so as to approximate the normal current flow conditions as closely as possible.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

In answer to the question by H. B. in the January issue of INDUSTRIAL ENGINEER, the following methods should be used: For a two-pole armature the lampbank is placed on the 180-deg. points. For a four-pole armature the lampbank is placed on the 90-deg. points. For a six-pole armature the lampbank is placed on the 60-deg. points. For an eight-pole armature the lampbank is placed on the 45-deg. points.

The rule is to place the lampbank leads on the points corresponding to the spacing of the brushes on any multi-polar machine.

As the meter leads are touched to adjacent commutator bars around the armature the readings should be the same, or very nearly so, for a perfect armature. A double voltage reading indicates a defective winding between the two adjacent bars. This may be a short-circuit between two coils, or a double ground. A reversed reading on any one section indicates a reverse connection to the commutator. No reading between two adjacent bars would indicate an open circuit to one or both of these bars. In that case by bridging these two bars, or one of them, and making contact with the bars on each side a higher reading than normal will result.

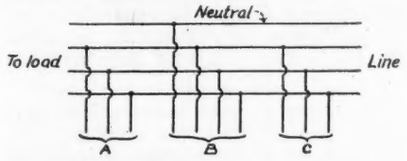
In passing from one section, such as a quarter-section on a four-pole armature, to another, the reversal of the meter leads is necessary due to the winding of the armature. However the readings should all be of the same value across any two adjacent commutator bars.

H. B.'s second question would indicate that an open circuit existed on the two bars that showed no reading. Under service this armature would show a heavy spark lapping over these bars when they came under the brushes.

One of the worst troubles to encounter is a "flying ground" wherein a connection of the coil becomes grounded only when the motor is up to speed, due to centrifugal action. In this case the method of testing is to mount the armature in a cradle and rotate it by another motor at the normal speed. A test set can then be used with one lead on the commutator and the other on the shaft of the armature. When the speed is correct the ground will show and it can usually be located by allowing a heavy current to pass through the test leads on the revolving armature. The commutator bar connected to the defective soil will show a pit where the circuit is broken under the lead on the commutator. Care should be taken to have the lead pressing upon the commutator at a point other than where the brushes will ride. Also care should be exercised to see that the current is not heavy enough to cause a heavy pit in the commutator.

Armatures can be tested in the frame, thus eliminating disassembly, by using two adjacent brushes reversed and lifting the others from contact with the commutator. The low-voltage leads are then connected to the armature leads on the motor terminal block. The armature should be wedged to prevent rotation when this procedure is followed. NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

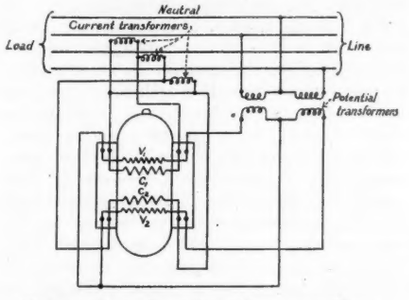
Connecting Westinghouse Type C Watt-hour Meter to 3-Phase, 4-Wire Circuit—Will some reader please tell me how to connect a Westinghouse, type C, switchboard, induction watt-hour meter to a three-phase, four-wire system having 2,300 volts between the neutral and each phase wire and 4,000 volts between phases? In the diagram, *A* and *C* are three-wire circuits supplying current at 4,000 volts, three phase, while *B* is a three-phase, four-wire circuit. One meter must measure the total power consumed.



The current transformers must be delta connected and three 2,300-volt voltage transformers must be used, as there are no 4,000-volt transformers on hand. I should also like to know whether it makes any difference if two or three current transformers are used on feeders *A* and *C*.

Guayama, Porto Rico. R. S.

Answering the question by R. S. in a recent issue, I assume that it is desired to measure the total energy of circuits *A*, *B* and *C* by a single meter.



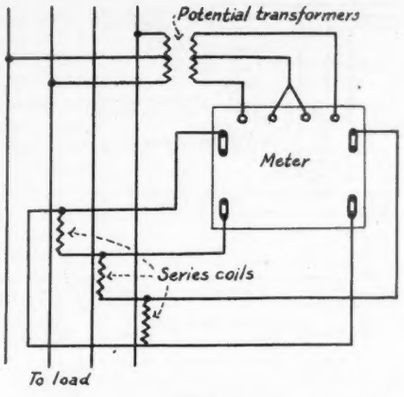
Internal and external connections of type C watt-hour meter connected to three-phase, four-wire circuit.

The diagram shows the conventional method of connecting this type of meter; the secondary current transformer connections only are shown. In the diagram V_1 and V_2 represent the voltage coils and C_1 and C_2 the current coils. I have attempted to show the connections at the terminal board as closely as possible in their actual physical arrangement. As previously stated, a meter so connected in the supply to circuits *A*, *B*, and *C* will register the total energy consumption of the three. On circuits *A* and *C*, if it is desired to measure the energy separately, two current transformers will be sufficient to secure proper registration.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

* * * *

In reply to R. S.'s question in a recent issue, the diagram shows a standard hook-up using delta-connected current transformers. This diagram shows the connection used for a four-wire, three-phase meter, which must be used, as a three-wire meter will not give accurate readings. A four-wire meter differs from a three-wire meter, mainly in the current coils. The four-wire meter has four series coils, two of which are connected in series and



Method of connecting type C Westinghouse watt-hour meter to four-wire, three-phase circuit.

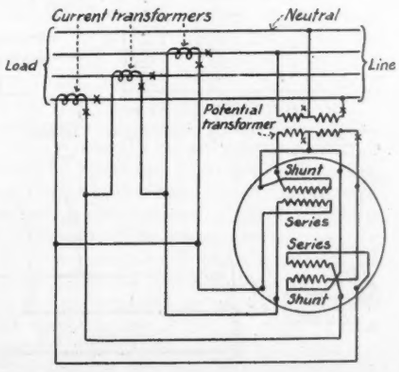
carry the current in one line wire. One coil in each element must be taken for the foregoing connection. The other two series coils, one for each element, are separate and each carries the current in one of the other line wires. The total energy will be registered when the meter is connected in this manner in a four-wire circuit, no matter how much out of balance the load may be.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

With reference to the question by R. S. in a late issue, the windings in a meter consist of a set of current coils and a set of potential or voltage coils. The current coils must be connected in series with the current to be metered and the potential coils connected in shunt with the circuit on the *line* side of the meter. In the diagram it will be noted that the common point of the primary of the two potential transformers is connected to the neutral wire of the circuit, and the remaining two primary wires are connected to any two of the remaining three wires of the circuit. This makes it possible to use two 2,300-volt transformers for the potential circuit of the meter. As regards using two or three current transformers in branch circuits *A* and *C*, two current transformers in each circuit will be sufficient, but as the total energy is recorded on the three-phase,

Internal and external connections of type C watt-hour meter to three-phase, four-wire circuit.



four-wire meter, it will not be necessary to meter these circuits unless the consumption of these circuits is to be checked against the total meter reading.

Goldfield, Nev. PHIL D. COMER.

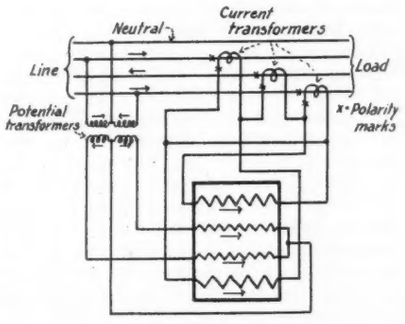
* * * *

In answer to R. S.'s question in a recent issue, the sketch shows the correct connections for a type C Westinghouse switchboard watt-hour meter. In this connection three current transformers are used, one in each phase, and two potential transformers of 2,300-volt primary rating are connected to two phases and the neutral; that is one side is connected to the phase wire and the other to the neutral.

The potential transformers that he mentions can be used and are the correct ratio, 20 to 1, for this installation. One phase is dropped in this four-wire connection due to the fact that all we need is potential of equal voltage on three wires; so with a pressure of 2,300 volts on the primary we will have 110 volts on our secondaries, the same as if this were only a three-wire circuit.

Galva, Ill. C. W. ROSELLE.

Method of connecting Westinghouse type C watt-hour meter to three-phase, four-wire circuit.



Method of Driving One Generator with Two Engines—Can some reader suggest a practical and efficient method of driving a 50-kw alternator by two oil engines of 37½ hp. and 50 hp., respectively, so that either or both engines may be used singly or together? If it is possible to devise such a drive with these engines operating singly or together I would have a selection of three horsepower capacities, 37½, 50, 87½, with which to meet the power demands. The peak load is about 45 kw., but the load is often much less than this. With such an arrangement it would not be necessary for me to buy a second alternator and install synchronizing equipment.

I shall be very grateful for any advice or suggestions you can give me.

Youngstown, Alta., Can. W. C. A.

In answer to W. C. A.'s question in a recent issue, I would like to tell him of an installation that was used for a number of years in a rolling mill in the Birmingham district. The mill was driven by an engine and a motor; they were placed in line one behind the other. The engine was behind the motor and had a larger pulley; so it was easy to place the motor drive pulley between the two sides of the belt on the engine. As the speeds of the engine and motor were different, the pulleys were also of different diameters. The motor belt was next to the pulley and the engine belt ran on top of the motor belt. This drive gave

satisfaction and was a good way to utilize the two prime movers.

To adopt this method of drive to your problem, I would suggest that you put a clutch on both engines and drive the generator in the same manner as outlined above. Or the generator shaft could be extended and an engine fastened to each end. If this method of drive were used, there would have to be some kind of clutch or magnetic coupling between the engine and generator to allow either engine to be used independently of the other. I believe, however, that a belt drive would be the most satisfactory, as the two engines probably run at different speeds and this condition could easily be taken care of with a belt drive.

GRADY H. EMERSON.
Birmingham, Ala.

* * * *

Lay Out of Typical Three-phase Installation—Will some reader give me (1) a diagram of a typical, three-phase power installation from the power company's wires to switchboard, including transformers? (2) What transformer connection is used most, and why?
Windsor, Ont., Can. J. A. L.

In reply to J. A. L.'s inquiry in the February issue, much will depend upon the voltage, location and amount of power to be purchased. A large consumer, who is served directly from a high-voltage transmission line, will usually have a small outdoor substation with high-tension disconnect switches, lightning arresters, step-down transformers, sometimes with a high-voltage oil switch on the primary side, and an oil switch on the secondary side. Inside of the substation there will be the meter transformers and the connections to the consumer's bus. The location of meter transformers depends upon the form of contract with the power company, but these usually provide for current to be furnished at the secondary voltage, in which case the meters are located as described.

For small consumers in cities, distribution is usually at 2,300 volts, in which case the hook-up is usually from the power company's line through high-tension fuses to primaries of transformers, from secondary of transformers to consumer's oil switch, which should be provided with overload relay but need not have no-voltage protection—this being on the individual motor lines—then through the meter transformers to the consumer's bus.

It is preferable to have the step-down transformers three single-phase transformers connected in delta, since if anything happens to one of them, the remaining two can be connected in open delta and about 58 per cent of the capacity of the original three obtained while the third is being repaired.

J. A. L. should consult the local authorities as all power companies and most localities have individual requirements which must be satisfied before the installation will be approved for service.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.
New Haven, Conn.

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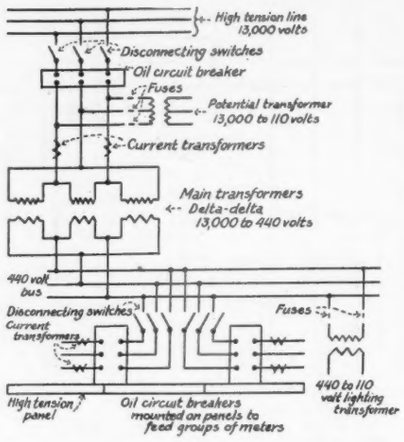
In answer to J. A. L.'s question in the February issue, (1) if the high tension lines are not over 22,000 volts, the disconnecting switches, high-tension



Layout of typical three-phase power installation receiving energy at 13,000 volts.

circuit breaker and transformers may be placed inside of the building, the breaker being mounted on a pipe framework and controlled by pipes and bell cranks from a panel in the same switchboard as the low-tension breaker. If the voltage is over 22,000 volts, all high-tension apparatus should be installed out of doors and the circuit breaker electrically operated. Low-tension breakers may be mounted directly on the panels, or on a pipe framework. The high-tension panels should have a wattmeter, voltmeter and ammeter with switch so that it will indicate current in all phases. Each low-tension panel should have an ammeter with switch and one panel should have a voltmeter connected through fuses to the low-tension bus. The diagram shows a typical three-phase layout.

(2) The most common transformer connection is the delta-delta. If trouble should develop in one transformer it may be cut out and the remaining transformers operated open-delta. Under these conditions, the two transformers will have about 58 per cent of the original capacity. Another common transformer connection is the star-delta with grounded neutral. The advantage of this connection is that the voltage stress to ground on the transformer insulation is only 58 per cent of the line voltage. If the high-tension side is delta-connected, the insulation is subjected to the full line voltage. The disadvantage of the star connection is that in case of trouble with one transformer it must be repaired or replaced before service can be resumed.
Boulder, Colo. RALPH MCKINNEY.

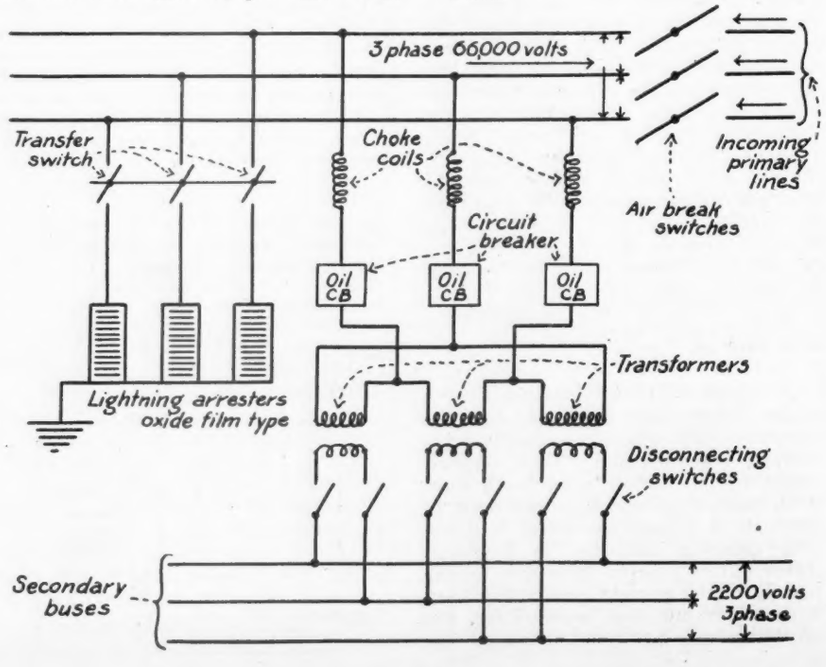
* * * *

In answer to J. A. L. in the February issue, I hope that the accompanying diagram of a three-phase installation will answer his first question.

The delta connection is the most frequently used transformer connection for ordinary industrial installations, as it is more convenient in case a damaged transformer has to be taken out of service. All that is necessary is to disconnect and remove the damaged transformer; then the two remaining transformers can be operated in open-delta. The capacity of the bank of transformers will be reduced to 58 per cent of its original capacity, but to that extent service can be maintained. In other words, one of the big advantages of this connection is that three-phase power is still available with two transformers, without any change in connections. As a general proposition, the delta connection ranks first in convenience of operation, second in low potential stress on the windings and fourth in low first cost. Many power companies use both star and delta connections, or a combination of both in order to be able to make changes in line voltage conveniently to meet new conditions.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

This diagram gives the layout of a typical three-phase power installation.



Voltage Rating of Fuses for 440-Volt Circuits—Will some reader please advise me as to the proper kind of fuses and fuse cutouts to use on 440-volt, three-phase, 60-cycle circuits? Should I use 600-volt or 250-volt fuses and cutouts? (2) Is it practicable to use fuses above 300-amp. rating as entrance fuses, or would it be better to use a circuit breaker?

Any information that you can give me will be greatly appreciated.

Marion, Ohio. G. R. K.

In answer to G. R. K.'s question in a recent issue, I would advise using 600-volt fuses and cutouts, although there are now some types of switches, fuses and cutouts on the market that can be used for 250 volts d. c. or 440 volts a. c. Personally I always insist on Buss refillable fuses, as they are very reliable and save a lot of trouble. They are manufactured by the Bussman Manufacturing Co., St. Louis, Mo. Single-pole cutouts are used now practically everywhere.

A circuit breaker could be used on the 300-amp. circuit but it is not needed, as nearly all authorities allow 600-amp. on fuses, if the voltage is below 600. I know of several installations that have 1,000-amp. fuses. However, it is good practice to use circuit breakers on 600 amp. or above. Switches and cutouts for high amperages usually have two or more clips and blades, and require several fuses, in parallel.

GRADY H. EMERSON.

Birmingham, Ala.

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Answering G. R. K.'s question in a recent issue, 600-volt fuses are the proper ones to use for this service. This will, of course, require the use of 600-volt switches and fuse blocks, which is only reasonable since the spacing of current-carrying parts of different polarity are much greater in 600-volt than in 250-volt equipment.

In regard to the use of fuses larger than 300-amp. rating, since fuse replacement in the large sizes is expensive, the best practice is to use circuit breakers except where fuses would rarely ever blow. L. T. JOHNSON.

East Cleveland, Ohio.

* * * *

Answering G. R. K. in a late issue, there is a little book, not hard to obtain, which will be found to contain answers to many questions on wiring which come up, from time to time, in these columns. That book is known as the "National Electrical Code" and it is the writer's belief that a copy of it should be in the hands of anyone interested in wiring as, without it, many costly mistakes may be made and, even if it is not needed to prevent mistakes, it will give much valuable information in regard to what is considered to be the best standard practice.

In the Code fuses are not rated as "250 volt" or "600 volt," but they are described as being for "Not over 250 volts" and "Not over 600 volts." A 440-volt circuit would, therefore, need what is ordinarily known as a 600-volt fuse.

In his second question G. R. K. asks whether or not fuses above 300 amp. rating are practicable as entrance fuses. Larger fuses are made and are entirely practicable under certain conditions. But the load should be a steady one, never approaching the rated capacity of the fuses which, in turn, should be protected by many smaller fuses in the branch circuits. Under such conditions the main fuses are not liable to blow except from a short-circuit near by or some other unusual condition which would seldom occur.

Where the load is a swinging one with sharp peaks, as in many motor installations and, therefore, a fuse would often be blown, the circuit-breaker would be preferable. This would be true in all cases where the saving in time by closing a breaker, instead of replacing a fuse, is important.

Westfield, N. J. G. H. MCKELWAY.

* * * *

Using Vacuum Pump as Air Compressor—I have a Wahl vacuum pump, size 4 in. by 2½ in., with ¾-in. inlet and outlet, which I wish to use as an air compressor. The pressure in the air tank need not go over 125 lb. per sq. in. Will someone please tell me, (1) What size motor would be required to drive this pump at 275 r.p.m.? (2) Will it be necessary to make provision for cooling this pump artificially, by means of air fins or water, in order to keep the temperature down to a safe limit? (3) How do you figure the cubic inches of air compressed per stroke?

Dallas, Tex. R. E. L.

In the March issue R. E. L. asks whether he can use one of our vacuum pumps as an air compressor, to work at a pressure of 125 lb. per sq. in. This vacuum pump is designed to produce a vacuum of 28 in., maximum, and will not stand a pressure of 125 lb., at any speed. While the writer believes that there would be little immediate danger of the pump breaking, the factor of safety used in designing it was not such as to advise a pressure in excess of 20 lb. per q. in., regardless of the speed at which it is driven.

Director of Sales, R. A. KIEFER.
Quincy Compressor Co.,
Quincy, Ill.

* * * *

Referring to the questions by R. E. L. in the March issue of INDUSTRIAL ENGINEER, the vacuum pump, with some modifications, can be adapted to be used as an air compressor. The ¾-in. inlet is satisfactory, but the delivery or outlet should be changed to a ⅜-in. or ¼-in. check valve. Considering the bore of 4 in. and stroke of 2½ in., the speed of 275 r.p.m. is high and difficulty may be experienced in the functioning of the valves. At a speed of 275 r.p.m. the pump has a capacity of approximately 5 cu. ft. of free air per minute, and based on continuous duty would require a 1¼-hp. motor, or 1-hp. on intermittent duty. At 150 r.p.m. the capacity would be approximately 2.75 cu. ft. of free air per minute and a ¾-hp. motor would be required. At this speed the efficiency would be much higher and heating lower.

Air cooling through the use of fins or ribbing might be sufficient, although it is somewhat questionable, depending upon how effectively the arrangement can be made. Some artificial means of cooling will be necessary.

In the foregoing I have assumed, of course, that the thickness of the metal and the general design of the pump are such as to allow it to be used at the pressure mentioned in the question.

The volume of free air compressed per stroke is given by the formula: $V=d^2\times0.7854\times S$, where d=bore of cylinder in inches, S=stroke in inches, and V=volume in cubic inches.

Engineering Dept., E. H. LAABS.
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

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Trouble With Rewound Automobile Generators—I have been rewinding some automobile generators, but in spite of the fact that I always check up the old winding and make the new one as nearly like it as possible I sometimes have trouble in getting the proper amperage out of the generator. The voltage will be up to normal, six volts, but the charging rate is too low. I wish some reader who has had experience in such work would give me some suggestions as to where the trouble may be.

Bathurst, N. B., Can. H. J. M.

Answering H. J. M. in the March issue, if his winding is correct, he may find his trouble in the charging control of his generator, which is dependent on the make and is capable of regulation. This control is often used by the motorist in touring where much of the driving is done in the day time. If H. J. M. wishes to check up on the principles or operation of this control the information can be secured from the manufacturer, the dealer or a garage man.

West Allis, Wis. EDWARD JAMES.

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In his question in the March issue, H. J. M. says that he can get only six volts out of a generator which he rewound. To charge a six-volt battery on a car requires eight or nine volts from the generator, in order to overcome the voltage from the battery.

The usual reason for generators not having the output they should, is because the throw of the leads has been slightly changed. When an armature is torn down, the top leads should be marked with a center punch where they come out of the slot in the core and the bars that they go into on the commutator should also be marked. The span of the coils should likewise be noted, as well as the bars to which the bottom leads are connected. In some armatures there is what is called a dead coil. This should be put into the same slot that it occupied originally. If the leads do not go back into the same slots in the commutator, the brushes will not set on the correct bars and the generator will not develop its rated output. Owing to the low voltage, a slight change in the setting of the brushes will make a big difference in the charging rate.

The rewound armature should always have the same number of turns of wire in the coils as it had originally. If the winder has difficulty in getting the wire into the slot, owing to a slight variation in the size of the wire, it is better to use a wire one size smaller than to wind the coils with a smaller number of turns.

We have rewound a great number of armatures with wire that was one size smaller than that used originally and we never had any trouble with heating up on that account.

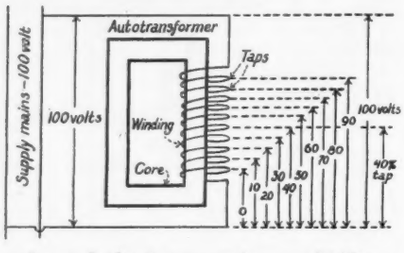
I am inclined to think that his trouble lies in not getting the leads in the right relation to the slots in the armature.

Peoria, Ill. GEORGE D. RINGNESS.

Calculating Starting Resistance for D.C. Motors—Will someone please tell me how the amount of resistance that is used in the starting rheostats of shunt, compound and series d.c. motors is computed? (2) How are the different voltages obtained on the various taps of the compensators for a.c. motors and what are their usual values in percent of full-line voltage?
Albert, W. Va. F. H.

To answer F. H.'s first question in the February issue we must go back to the fundamentals of electricity. Assume a 250-volt motor with 0.25-ohm armature resistance, drawing 100 amp. under full load. According to Ohm's law, I=E÷R; therefore, substituting the above values, I=250÷0.25 or 1,000 amp. A current of this magnitude would destroy the machine.

The starting rheostat would have to be designed to prevent this high current flow. If we have a rheostat with 2.25 ohms resistance which, with the armature resistance of 0.25 ohms would give a value of 2.5 ohms, the equation would then be, I=250÷2.50, or 100 amp., which does not exceed the current value of the motor.



Any desired percentage of line voltage may be obtained by taking taps at proper points on the winding of an auto-transformer.

At standstill the armature presents the very low resistance of only 0.25 ohms, but as it comes up to speed it generates a counter-emf. which makes it necessary to cut out resistance as the motor speed increases. When the motor is running at a little more than half-speed, the counter-emf. will be around 125 volts. If the motor attained this speed with all of the rheostat resistance in circuit, it would be drawing only 50 amp. as the rheostat resistance would remain at 2.25 ohms and the internal resistance at 0.25 ohms. Therefore, at this value enough rheostat resistance should be cut out so that there will be only 1.25 ohms in the circuit. Then the equation will be, I=125÷1.25, or 100 amp. This gradual reduction of resistance is carried out in a number of steps until the motor is connected directly across the line.

It can readily be noted that if the rheostat is cut out too fast the motor will draw an excessive current due to the fact that it has not attained speed enough to generate a counter-emf. in proportion to the applied voltage and the resistance being cut out of the circuit. On the other hand, if the motor is advanced too slowly the starting taps, resistance, etc., will be endangered, as they are designed only for momentary service and not for speed control, which is something entirely different.

With reference to his second question, a compensator is essentially a transformer with only one winding, a portion of which acts as both the primary and secondary winding. Almost any desired voltage lower than the applied voltage can be obtained from it by taking off taps at the proper point. I believe this is made clear in the illustration, which shows an elementary design of auto-transformer, operating from a 100-volt supply and provided with 10 taps from which any voltage from 0 to 90 volts can be obtained in steps of 10 volts.
West Allis, Wis. EDWARD JAMES.

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Replying to F. H. in the February issue, an auto-transformer or a compensator has only one winding which is wound on an iron core and serves both as high- and low-tension winding.

If connected across a source of voltage the fall of potential along the winding is in proportion to the number of turns and any voltage lower than the applied voltage can be obtained by taking taps off the proper points on the coil.

For alternating-current motors, the compensator supplies a reduced voltage to the motor circuit while the machine is accelerating from rest. Ordinarily, each auto-transformer is provided with several taps so that a number of low voltages may be obtained. Compensators can be adjusted to give 50, 65 and 80 per cent of line voltage with respective line currents equal to 25, 42 and 65 per cent of the current that would be taken by the motor if no compensator were used. In order to keep the starting current as low as possible, it is important to select the lowest taps that will start the load. To obtain full-load torque at starting requires about 80 per cent of normal voltage.
Brooklyn, N. Y. HALSEY DEGRAW.

* * * *

With reference to an inquiry by F. H. in the February issue, calculation of resistance for direct-current motor starting rheostats, when treated theoretically, is somewhat involved. However, the following method will serve for ordinary industrial application in temporary or emergency cases: Compute maximum allowable starting current—this is generally assumed to be from 1.5 to 2 times the full-load current of the motor, depending upon the nature of load to be started. Then employ sufficient resistance between the first active contact point and the last to limit the current to the above value.

Steps should be so arranged that the amount of resistance cut out is less for each succesive step approaching the all-out position. For example, in an exaggerated case the figures for comparative resistance of a starting box from the first to the last step, six points being used, might be given as 15-9-5-1-½-0. The carrying capacity of the resistance element used is also generally increased toward the last steps.

Complete data sheets giving resistance, carrying capacity, etc., can be had from manufacturers of resistance alloys. Driver-Harris Company, Harrison, N. J., will furnish information of this nature.

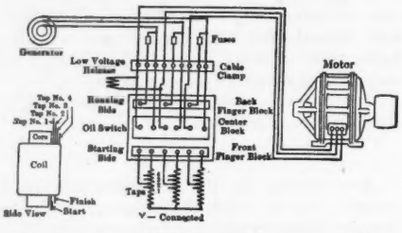
For starting a. c. motors, an auto-transformer is usually employed. Different voltages are obtained by tapping the winding at points corresponding to the desired starting voltage. The usual percentage of these taps, with reference to full-line voltage, is as follows: 50, 65, 80 and 100.
Baltimore, Md. EDWARD H. HAUSLER.

* * * *

With reference to the question by F. H. in the February issue, (1) if full line voltage were passed through the armature of a direct-current motor at standstill an excess of current would flow and cause damage. Consequently, a starting resistance has to be used to limit the current until the counter-emf. has built up to the proper value. The problem then, is to determine the resistance which must be used to keep the current flow down to a safe value.

According to Ohm's law R=E÷I, where *E* equals voltage, *I* equals current in amperes and *R* equals resistance in ohms.

For the application of this law, suppose we have a 10-hp. 110-volt motor which takes 90 amp. when fully loaded. The armature resistance is 0.05 ohms.



Internal and external connections of auto-starter for alternating current motor.

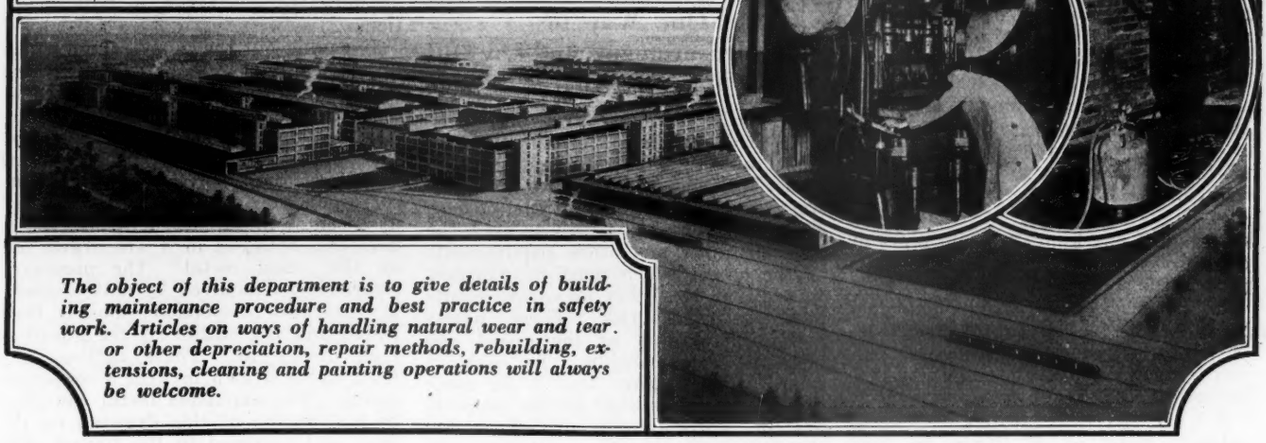
What value of starting resistance should be used, assuming that the starting current is to be 100 amp.?

From the above equation, R=110÷100=1.1 ohms. The resistance of the armature is only 0.05 ohms so that the starting resistance will have to be 1.1-0.05=1.05 ohms.

In a series motor, the field is in series with the armature and, therefore, its resistance must be added to that of the armature when making the above calculation. In the case of a compound-wound motor, the same allowance must be made as for a series motor.

(2) The diagram shows how the different taps are obtained and the auto-starter and motor are connected. The coils of an auto-starter are nothing more than an auto-transformer connected star. The coils are connected directly across the line when the motor is started. The lower starting voltage is obtained by means of taps taken off at different points on the windings. Usually three values of voltage are available. The first tap gives a voltage of 40 to 50 per cent of the line voltage; the second tap gives from 65 to 70 per cent, and the third tap gives about 85 per cent. The selection of the proper taps depends upon starting conditions. If the motor has to start under heavy load a tap giving a higher voltage value is chosen. Conversely, a lower-voltage tap is used if the motor does not have to start under heavy load.
Brooklyn, N. Y. MICHAEL REUTER.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear, or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Special Saw Rigged Up to Cut Out Wooden Flooring

CUTTING out wood flooring for the placing of new machinery on a concrete base, proved a slow and difficult operation in one industrial plant until the circular saw shown in an accompanying illustration, was put on the job. This saw is driven by a portable electric drill mounted on a special carriage consisting of a two-wheel tote truck, such as is ordinarily used for hauling small tote boxes around the plant. This truck may be purchased at a cost of $3 or $4 from almost any mill supply or machinery house.

In attaching this saw, two holes are drilled in the frame of the tote carriage, through which two screws are run into the regular tapped holes in the top head of the electric drill. The other end of the electric drill is supported by a board. The spindle housing of the drill fits snugly into a hole, which is drilled in the approximate center of the board. One end of this board is held firmly by slipping the axle of the tote carriage through the end; the other end is supported by the two bolts ordinarily used to hold the frame to the handle of the tote carriage.

The drill in the illustration is a $\frac{1}{8}$-in. capacity electric drill (The Van Dorn Electric Tool Company, Cleveland, Ohio) on which the chuck is threaded to the spindle by a right-hand thread. As the diameter of this spindle is ½ in., an 8-in. diameter saw with a ½-in. hole is used. To attach the saw, it is simply necessary to unscrew the chuck from the spindle of the electric drill, slip the saw onto the spindle and use the regular, threaded back chuck to hold the saw in place.

The outfit shown in the illustration was used to cut out wood flooring 2 in. thick. A similar operation is frequently encountered in many plants when it is desired to remove a portion of the flooring in order to permit the mounting of heavy machinery on a concrete foundation or when it is desired to remove sections of the flooring for repairs. With this outfit a neat job with a good straight edge can be obtained, and there is not the tendency to split some of the flooring that is not to be removed, as is the case when some other methods are employed. For example, one of the common methods used to remove flooring is to drill holes at the four corners of the section which it is desired to remove, and then use a hammer and chisel.

An electrically driven saw of this sort does the work in about one-fifth the time usually required by hand. It would not take many such jobs to make it pay for itself.

With this special carriage and saw wooden flooring can be cut out in about one-fifth the time ordinarily required.

In addition, the saw does a much cleaner job. This outfit can easily be made up by using a portable electric drill, a saw and a small truck for tote boxes. This truck can either be purchased, or made at small cost.

Rules Governing Fire Prevention in Industrial Plants

PREVENTION of fires in industrial plants is largely a matter of painstaking care in the avoidance and removal of the conditions which cause fires. In many plants the primary causes of fires are not recognized or considered and there are no clearly defined regulations or inspection which will safeguard the property.

Observance of the regulations given below is essential to any fire-prevention program. They embody precautions which apply generally to any manufac-

turing establishment and represent a thorough consideration of the ordinary causes of fires as shown by reports over a long period of time in several plants.

Fire Prevention Regulations

1. Fire hydrants, extinguishers, hose, and other firefighting equipment must be kept clear of obstructions at all times, in order to permit quick and convenient access to them.

2. Defective wiring, leaky steam pipes, etc., must be immediately reported to the superintendent.

3. Putting overalls or other greasy clothing, waste, etc., in lockers is prohibited.

4. Hanging clothing, towels, or cloth material of any kind on steam pipes or close to exposed electrical wiring is prohibited.

5. Electrical work is to be done only by the employees of the electrical department. Unauthorized lights, fixtures, inflammable shades, etc., are prohibited.

6. All electrical switch and panel cabinets must at all times be kept closed. In case temporary connections have to be made, such cabinets must be closed as completely as possible without injury to such temporary connections.

7. Forges, open lights, and fires must not be left unattended, and must be extinguished before closing time.

8. Before closing, all buildings must be cleared of inflammable refuse, and trash cans emptied or taken outside. Material such as waste, oil, etc., must be kept in the proper receptacles provided for that purpose.

9. Unduly high temperatures in buildings must be investigated and reported at once to a foreman or the superintendent.

10. Unslaked lime and all inflammable materials must be kept only in places designated by the superintendent.

11. Smoking in the plant is prohibited, except at such times and places as permitted by the superintendent. Safety matches only may be carried or used in the plant.

12. An inspection of all buildings and fire apparatus will be made every two weeks by an employee designated for this purpose by the superintendent and a written report of each inspection will be made.

Washington, D. C. G. A. LUERS.

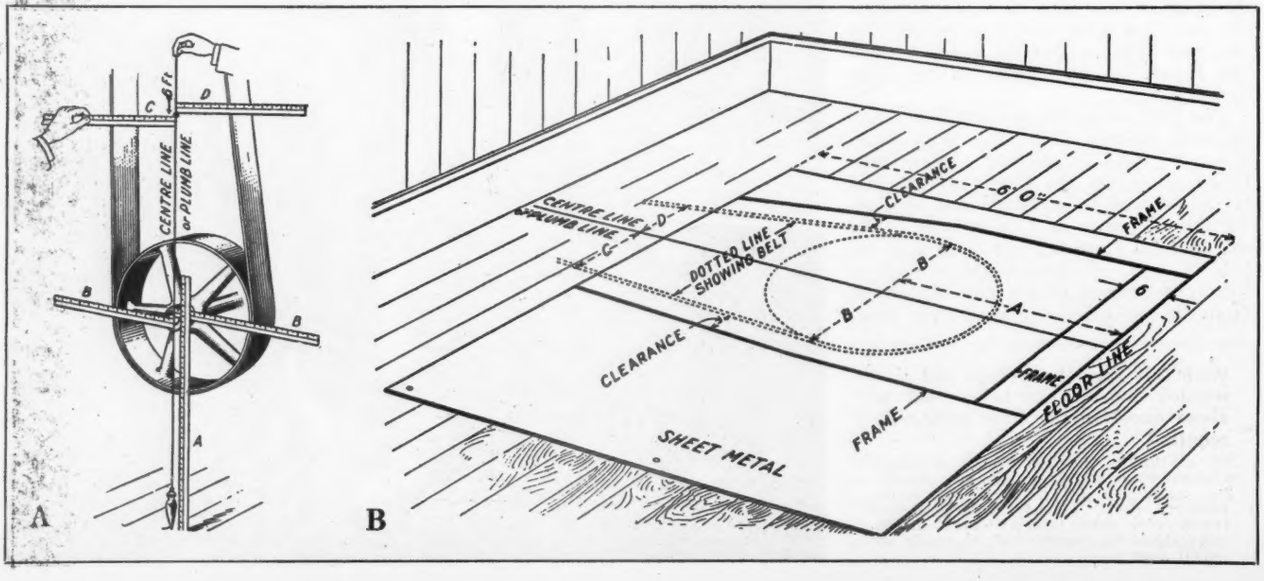
One Way to Take Measurements and Lay Out Machine Guards

WHEN making guards for industrial machines, perhaps the first point to take into consideration is to make sure that they conform with any state or insurance regulations. These cover the type of guard to be used, the size, clearance and other requirements of the object which must be guarded. In addition, two other important points must be considered. These points cover the rigidity of the guard and also the workmanship. To make a guard rigid requires that it be made of the proper material and be properly braced. Workmanship also affects the rigidity of the guard as well as its appearance. Other important factors affecting appearance are the care and accuracy exercised in laying the guard out properly.

Suggestions for measuring an installation and laying out the guards are given by the Consolidated Expanded Metal Companies, Braddock, Pa., for guards made of "Steelcrete," an expanded metal. While taking these measurements is one of the most important, it is also a simple operation in the construction of machine guards. The method of taking these measurements is shown in *A* of the accompanying sketch. In this a knot is made in the plumb line at a point 6 ft. from the tip of the plumb bob. This is held so that the tip of the plumb bob touches the floor and the line passes through the center of the pulley shaft. This plumb line then becomes a center line and from it all essential measurements as indicated are taken in both directions.

In laying out the guard, these measurements are first transferred full size on to a plain surface. One method of doing this is shown in *B*. A good, practical drawing surface may be made by fastening a few light-gage black metal sheets to the floor. A vertical line corresponding to the plumb line is used as a center line and the various measurements obtained in *A* are drawn out on this sheet metal. The necessary clearance as required by state factory or insurance inspection rules is then added and the outline of the guard is then drawn in. These outlines are most easily drawn in with a soapstone pencil. The expanded metal can then be laid on top of this drawing on the floor and trimmed to the proper size, or the lines upon which the metal is to be cut marked on the expanded metal and then cut by a shears or by other means. It is customary to build one side of the frames of the guards at a time. The angle iron is cut, bent, and fitted exactly to conform to the outline. The expanded metal after it is cut to size is then fitted and fastened to the angles.

Ordinarily, state or insurance regulations specify that guards for such drives as shown at *A* need be only 6 ft. from the floor, as that is considered high enough to prevent accidental injury. By far the largest item in the manufacture of guards is the labor involved. Ordinarily, the cost of material almost regardless of the kind or quality, will not be more than 15 or 20 per cent of the cost of the finished guard. For this reason, it is always an advantage to get a good grade of material and when spending the money for workmanship to see that only the best is put into it. A rough, unfinished guard is not only unsightly but may be unsafe.



Steps in taking the measurements and laying out a machine guard. The pulley and belt are measured with the aid of scales and a plumb line, as shown at the left. These measurements are then transferred to black sheet metal placed on the floor. After drawing the outline of the machine and adding the clearances, the outline of the guard is then drawn in and used as a templet for laying out the guard and the angle-iron frame.

Method of Making a Tripod From Conduit

A TRIPOD that will handle up to 1,500 lb. and which may be made from conduit, has been found very handy around our plant for making lifts over small machines that are not reached by the traveling crane. The legs of the tripod are made from three pieces of 1¼-in. conduit, each piece being 9 ft. long. Flatten one end of two of the legs for a distance of about 2 in. and bend the ends out a little. The third piece should have one end flattened for a distance of about 6 in. A ⅞-in. hole is drilled through each of the flat ends. The three flat ends of the conduit, together with a clevis about 6 in. long are then bolted together by means of a ⅝-in. bolt.

To the bottom end of each leg a pointed 1¼-in. solid rod is welded. This is done to prevent the tripod from slipping when it is set up. The chain block or block and tackle is hooked on to the clevis which is at the top of the tripod.

This tripod can be quickly set up over any part that has to be lifted. It will be found that one man can handle it easily. Also it can be folded together and put in the shop when not in use.

Chief Electrician, W. B. CONE.
Shevlin-Hixon Company,
Bend, Ore.

Comparative Costs on Three Types of Factory Floors for Trucking Runways

AFTER many years of experience on floor maintenance, I have decided that for our work the best material for trucking runways and for floors for heavy work, is the creosoted wood block. For several years I have experimented with different mixtures of concrete and surface hardeners, but my experience has been that the concrete did not stand up under our requirements. Certain spots seem to wear faster than others, small depressions result or cracks develop, and these soon grow into holes.

Furthermore, concrete does not lend itself well to any patching process. The patch is seldom a perfect bond with the old concrete and a crack usually develops at the bond. Another cause for the patch not standing up, is that the surface of the patch is new and hard, with a skin on it. The old concrete has the surface or skin fairly well worn off. Where the truck wheels move from the surface of the old concrete onto the surface of the new, there is a very slight bumping action which soon develops a depression at this point and as the truck leaves the patch the same thing is repeated and eventually gives two bad spots instead of one. No doubt, in some plants where the trucking is not severe, the concrete might show up better, but the trucking in our plant is extremely severe.

The plank type of runway is, I believe, to be preferred to concrete and has some good points but, unfortunately, several bad ones, also. I have obtained the best results with the planks laid so that the traffic was with the grain. This stands up well and is cheaper to install and to repair. It is better to lay the plank in the longest lengths obtainable as the less joints the better; trouble usually occurs first at the joints. Wood planks have the advantages of being dustless, noiseless and easy to repair, and the disadvantages of wearing rapidly and unevenly, and eventually splintering. Foot injuries often result when splintered wood runways connect up with a pair of badly-worn shoes. In some lines of manufacture, particularly rubber products, these splinters manage to get into the product and may cause serious trouble and complaints.

Cost Per Year of Factory Floors

Type of Flooring	Useful Life	Cost per Sq. Ft.
Concrete	8 years	4.1 cents
Hardwood plank.....	8 years	3.8 cents
Creosoted wood block	30 years	1.7 cents

Because of the disadvantage of concrete and plank flooring, I believe that the creosoted wood block is, all things considered, the best for our work and am using a 2½-in. by 3-in. by 7-in. block, 8 lb. treatment. These blocks when installed in runways on the ground floor of the plant, are set as follows: The foundation consists of 4 to 5 in. of well-rammed concrete, leveled off fairly well on top. The top of this concrete is finished off at such a depth as to allow for the thickness of the blocks and from ¼ in. to ½ in. of sand cushion.

After the concrete is well set, it is covered with a layer of lake sand, not too fine, and this is leveled off very slightly higher than the thickness of the blocks below the surrounding floor level. The blocks are then laid in place, end grain up, and driven tightly against each other. If the edges of the area cut out for the runway are uneven, (if in a concrete floor), pieces of 2-in. by 3-in. plank are laid along the edge and held in place by cross pieces which are removed as the work of laying the blocks progresses. These serve the purpose of a straightedge to lay the blocks against. After all the blocks are laid, they are covered with lake sand; this is swept well into the cracks between the blocks and then the whole surface is well tamped. The side pieces, serving as straightedges, are then removed and any openings left are filled with concrete. This finishes the runway straight and flush with the floor.

If the block runway is being laid in a plank floor, the edges of cut out area for the runway can be made straight and true without any trouble. We have had little need to use wood blocks on floors other than the ground floor, but it is entirely feasible. Our trucking on floors other than the ground floor is fairly light and tongue-and-groove hard maple, ⅞ in. thick, has been reasonably satisfactory when laid so that the traffic was with the grain.

Creosoted wood block is not expensive when its life is taken into consideration, although the first cost is higher than most types of flooring. The first cost is practically all the expense as the repairs for many years are nil. Our actual cost on the wood-block runway is 53 cents per square foot laid for the 2½-in. by 3-in. by 7-in. blocks. Of this amount, 28¼ cents covers the concrete foundation and laying of the blocks; the balance represents the net cost of the blocks. This cost would, of course, vary considerably according to the location of the plant. The cost of the material would be lower in the United States than in Canada, but the labor cost would be higher.

An estimate of the actual life of the wood-block runway would be about 30 yr. based on the following: Several tests were made on the busiest runways in our plant at points where the heaviest traffic is experienced, and after two years of service the maximum wear shown on the blocks was only 1/16 in. At exactly the same location, in a previous test on wood plank, the wear at the end of two years was ¼ in., or four times the wear on the blocks. Tests also showed that nominal 2-in. hardwood plank will, under heavy traffic, be reduced to 1 in. and less in thickness in eight years and is then in a dangerous condition.

A wood-block runway of 2½-in. blocks has the advantage of the additional thickness over the plank for extra wear. Also, if the blocks become too badly worn for easy trucking, they can be taken up without damage, more filling put under them, and releveled. With the plank floor it is necessary to turn it and it is nearly impossible to make a good job, because the planks nearest the sides of the runway are often not worn so much as those in the center and require a lot of shimming up and fitting. With the blocks, the ones at the edges which are not worn so much can be placed in the center when resetting and the worn ones placed to the edges; the difference in thickness is taken care of with the sand fill underneath.

The wood blocks are not dusty and are quiet. As they are end-grain, they have very little tendency to cut into ruts, especially as the directions of the end grains are mixed up considerably. Wood blocks are easy to patch and if a runway is changed in location, there is little waste in taking it up and moving it. In such a case the space left vacant by its removal can be filled solid with concrete; if located in a wood floor, stringers can be set in and a regular floor laid. Another favorable feature of the wood-block runway is that on account of the size of the blocks they can be laid to follow any inequalities in the floor level without any trouble. This, of course, can also be done with a concrete runway, but is a very troublesome problem sometimes with a plank runway, especially in old floors.

The actual costs of the three different types of runways mentioned in this article have worked out with us as shown in the accompanying table. This is based on cost per year, per square foot.

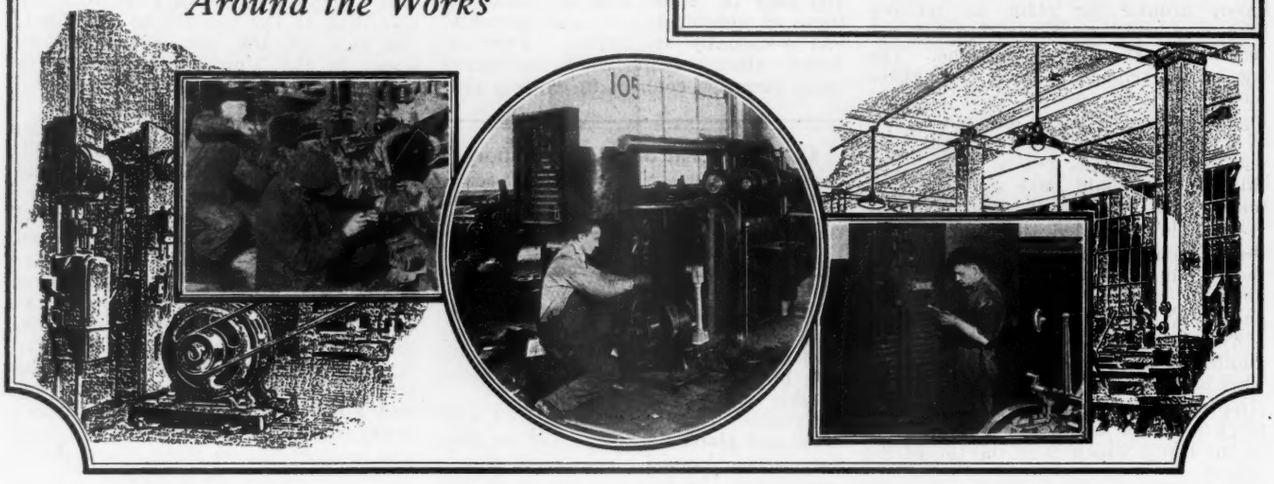
Some of the readers of INDUSTRIAL ENGINEER may not agree with me regarding this, and I would be interested in seeing some discussion along this line.

L. J. CLAYTON.
Assistant Mechanical Engineer,
Goodyear Tire & Rubber Co. of Canada, Ltd.,
Bowmanville, Ont., Can.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Comment on "Paralleling of Alternators Coupled to Same Shaft"

THE following interesting comment on the short article by R. S. Huntington, which was published under the above heading on page 153 of the March, 1925, issue of INDUSTRIAL ENGINEER, has been received from Mr. Carter of The Baylis Company. His suggested method of doing the job, together with Mr. Huntington's comments thereon, are given below.—EDITORS.

* * * *

In the method used by Mr. Huntington, the bolts were removed from the coupling connecting one alternator with the water wheel and the coupling tied together with cords strong enough to permit the alternators to be brought up to speed by the water wheel. Simple as this method was, I believe it could be simplified by omitting the tying together of the couplings. If the coupling were disconnected, the fields of both machines fully excited while they were standing still, and the switches paralleling the two alternators closed, when the water wheel was started, the generator, which is coupled to the waterwheel, would bring up to speed the uncoupled alternator as a synchronous motor. The field could then be adjusted and the coupling marked as described in the article mentioned.

Engineer, EDWARD D. CARTER.
The Baylis Company.
Bloomfield, N. J.

* * * *

I have read Mr. Carter's comments with interest. His suggestion is all right provided an independent source of exciting current of the proper voltage is available before the waterwheel is started. In the case mentioned in the article, however, the only exciter in the plant was coupled to the same shaft as the waterwheel and, therefore, no direct-current excitation was available until the waterwheel was running at a little better than half-speed.

The method of tying the couplings together with a piece of string was adopted as the simplest and safest method available for getting the uncoupled alternator up to speed in such a manner that the strain would be at a minimum when excitation was applied.

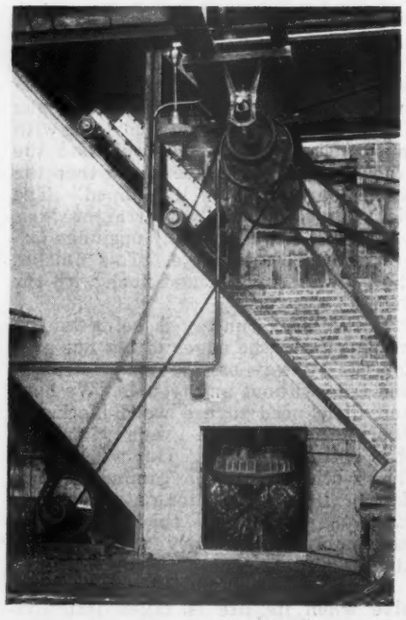
President, R. S. HUNTINGTON.
Huntington & Guerry, Inc.,
Greenville, S. C.

How a Lifting Magnet Is Used to Handle Steel Scrap

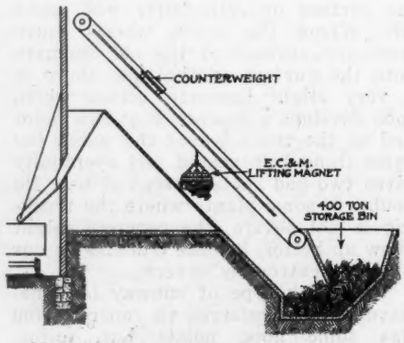
REMOVING and loading scrap upon railway cars is a troublesome problem in many industrial plants. This, however, has been satisfactorily solved at the Chicago, Ill., plant of Harrington & King Perforating Co., who are manufacturers of perforated metals for industrial screens and other purposes. As practically every production machine turns out scrap, a very careful study was made when the layout of their new plant was being drawn up, to determine the best means of handling and disposing of this material.

Now the scrap steel, as it accumulates, is carried to a 400-ton storage bin below the floor level at one end of the main building. To load the scrap from this bin into gondola cars, which are spotted just outside the building, the hoist shown in the accompanying diagram was constructed. This hoist is much on the order of a skip hoist, except that the skip has been replaced by a No. 3 E. C. & M. (The Electric Controller & Mfg. Co., Cleveland, Ohio) magnet. This magnet is suspended from a 45-deg. track which runs from the hopper below the scrap bin to a chute which has a spout dropping over a gondola car on the adjoining track. To cut down the power necessary to operate this system, the magnet is balanced by a counterweight which moves in a direction opposite to that of the magnet. The loaded magnet is driven through a friction drum by a 10-hp. E. C. & M. motor.

When the magnet is in its lower position, where it is resting on the scrap in the hopper, the current is turned on



This view shows how the magnet conveyor system for handling steel scrap is enclosed for safety. The door provides a means of inspecting the operation of the conveyor.



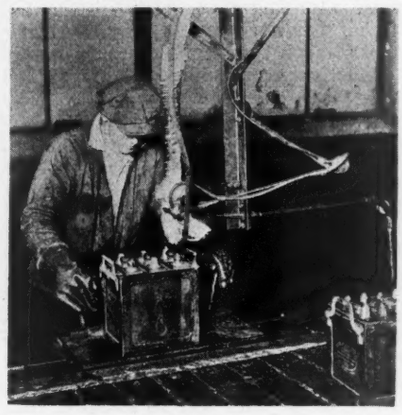
This diagrammatic sketch shows the arrangement of a skip hoist with a magnet for handling scrap steel.

and the magnet picks up a load of scrap. The operator then runs the magnet up above the loading chute, the magnetizing current is turned off and the load is dropped. By this unique arrangement, 20 tons of scrap an hour can easily be loaded. This means that with 62 trips in an hour, the magnet is averaging over 650 lb. per lift. In addition to reducing materially the handling cost on scrap steel, the company is receiving an additional $2 per ton for the scrap when delivered to the car instead of in the yard.

Application of Space Heaters in Battery Manufacture

HEATING the compound used to seal the covers into the cells of automotive storage batteries has always been a problem. For this compound to work best, the temperature must be maintained constant within a variation of 8 deg. or 10 deg. F. The heat conductivity of this material is so low that a hot plate under the kettle is extremely inefficient and slow, and, as this material is highly inflammable, open flames of any kind would be very dangerous.

This, and other similar problems, were solved about four years ago at the Westinghouse Union Battery Co., at Swissvale, Pa., by some unique applications of standard electric space heaters. As an example, for heating the sealing compound, space heaters were clamped solidly against the sides and bottoms of the compound tank and the tanks and heaters were then covered with sheet asbestos. The pipe which leads from the tank to the nozzle of the sealing machine, as shown in the accompanying illustration at the top of the page, is heated by passing a current of low voltage and high amperage through it. A thermo-couple that actuates a relay is inserted in this pipe near the nozzle.



The manufacture of storage batteries is simplified by the use of electric heat.

One of the big problems in the manufacture of storage batteries is to get the sealing compound to flow down into the battery through the pipes and seal the covers on to the cells. Space heaters, as described in the text, keep the compound warm in the melting tank and special arrangements to heat the pipe facilitate the pouring.

This relay, in turn, opens and closes the circuit leading to both the space heaters and the feed pipe, and so keeps the temperature well within the desired limit.

Another bothersome heating problem was in connection with the manufacture of soft metal storage battery grids. The grids have a light cross-section and are cast in metal molds. The illustration at the bottom of the page shows the workman closing a mold preparatory to casting. A pile of grids is shown at his right.

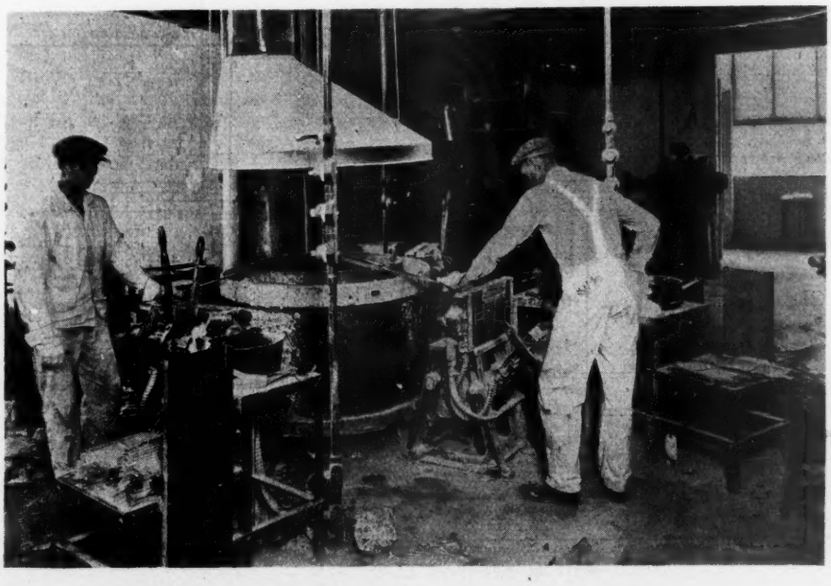
Unless the molds are at exactly the right temperature it is impossible to get good production of perfect grids. When an open flame was used to heat these molds, it was difficult to get the correct temperature; also the open flame was somewhat dangerous. Now, space heaters give the right sort of heating conditions. Three heaters are clamped on each side of the mold. These are connected in opposite pairs so that the operator can control the temperature of any part of the mold by means of a switch. No attempt is made to do this automatically because molds for different grids require different heats. Pilot lights indicate to the operator which pair or pairs of heaters are working at any time.

Electric heat is also used for lead pots, and for melting small quantities of lead, solder and other materials in various departments. In another department the application was in connection with the manufacture of long strings or "worms" of sealing compound about ¼-in. square. These squares are used cold and are extruded from a press. It was found that the press could not handle the cold compound well; so a pair of space heaters was clamped on the outside. These warm the press just enough so that the compound flows out of the press, at the proper consistency for use. Electric heat has been found very useful because of its safety, flexibility, and ease of control in many of these operations.

Production Engineer, P. E. NORRIS.
Westinghouse Union Battery Co.,
Swissvale, Pa.

By means of space heaters these molds are kept at the proper temperature for pouring the lead grids.

Unless these molds for casting the grids for storage batteries are at the proper temperature, the grids do not cast well. To remedy this three electric space heaters are clamped on each side of the mold. These are connected in opposite pairs so that the operator can control the temperature easily through a switch.



Simple Method of Interlocking the Control of Coal-Handling Equipment

COAL-HANDLING equipment for a small power station consisted of a pivoted-bucket carrier, which was used in conjunction with a rubber belt conveyor and a coal crusher. Coal was brought by rail in gondola cars to the power station where it was dumped into a hopper which led to the rubber belt conveyor. The belt conveyor carried the coal to the pivoted-bucket carrier, which in turn carried the coal to the top of the boiler house where it was fed directly into the coal crusher. These three machines were driven by separate motors. To prevent the coal from piling up in case one motor should stop, it was essential that all motors between this motor and the point where coal was received should shut down simultaneously.

It was found that this could be very easily accomplished by using standard General Electric enclosed across-the-line starting switches, type CR-7006-D5, and electrically interlocking them. This magnetic switch consists of a three-pole contactor, an extra pole which is provided for use as an electrical interlock, and a two-coil, hand-reset temperature overload relay. The relay has two heating elements, one connected in each of two phases, so that it provides full overload protection. After the overload relay trips due to an objectionable overload, the contact must be reset by a resetting device operated from the outside of the case.

The starting switches are ordinarily operated by means of a start-and-stop push button station. In case a con-

tactor opens due to failure of voltage it will not close automatically on return of voltage, but the start button must be pressed in order to restart the motor. Also, in the event of an overload causing the contactor to open it is necessary to reset the relay by hand before pushing the start button to start the motor.

Three of these starters were connected up as indicated in the accompanying diagram. It will be noticed that for the crusher motor the standard scheme of connection was used. The pivoted-bucket carrier motor and the belt conveyor motor were also connected up in a similar manner but, in addition, single-pole, double-throw snap switches were wired into the control circuits of the operating magnets of these two starters. Also, control wires were connected from one pole of the snap switch to the three-pole contactor of the adjacent starting switch, as is shown in the diagram.

For normal operation, both of the single pole, double-throw snap switches are closed as shown in the diagram. With this connection it is only necessary to push the start button of the crusher motor to start all of the motors. The sequence of operation is as follows: Pushing the start button on the crusher motor, closes the three-pole contactor starting this motor. As soon as the three-pole contactor of the crusher starter closes, power is supplied over the control wire to the operating coil of the pivoted-bucket carrier motor which, in turn, starts this motor. As soon as the three-pole contactor of the pivoted-bucket carrier starter closes, power is applied to the operating coil of the belt conveyor motor starter which causes it to function, starting the belt conveyor motor. Hence, it is seen that with this arrangement the pivoted-bucket carrier motor and the crusher motor must always be running before the belt conveyor motor can run and thus there can be no piling up of coal at any point in the system, due to the stopping of a motor.

If it is desired to stop the motor, the stop button on the crusher motor may be pushed which will shut down all motors or the snap switch on either of the other two motors may be turned which will shut down that motor. If the snap switch on the pivoted-bucket carrier motor is turned, that motor as well as the belt conveyor motor will be stopped. If the snap switch on the belt conveyor motor is turned, the belt conveyor motor only will be stopped, thus preventing piling up of coal anywhere in the system, should a motor be shut down.

When the snap switches are thrown to the position shown by the dotted lines in the diagram, the particular motor to which this snap switch applies is cut out of the interlocking sequence and can be operated independently by means of the start-stop button for testing purposes.

ROGER F. EMERSON.
Industrial Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

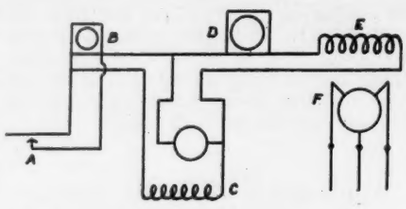
Diagram of connections for interlocking the sequence of starting and stopping of motors.

This control scheme was installed for controlling the operation of three motors driving the coal-handling equipment in a small power plant. To prevent piling up coal at any point it was essential that the crusher motor be running before the pivoted-bucket carrier motor was started. Likewise, it was necessary that the pivoted-bucket carrier motor be running before the belt conveyor motor was started. The control scheme shown in the diagram made the control of the motors follow this sequence.

How an Improvised Method of Regulating A. C. Voltage Kept a Plant Going

RECENTLY, it was necessary for an industrial plant to commence operations before the arrival of a voltage regulator. Since the load fluctuated rapidly and it was found impossible to regulate by hand, using the rheostats, the method shown in the accompanying sketch was devised. An ordinary telegraph key was connected across the terminals of the exciter rheostat so that when the key was closed the resistance was cut out, and when the key was opened resistance was introduced into the exciter field circuit, as shown.

In operation, the exciter field rheostat had its resistance all cut in, while the main rheostat in the alternator field circuit had its resistance all cut out. If the main resistance was cut in, excessive sparking took place at the telegraph key contacts, heating up the key and making it uncomfortable to operate. When the key was closed the voltage rose and when it was opened the voltage fell.



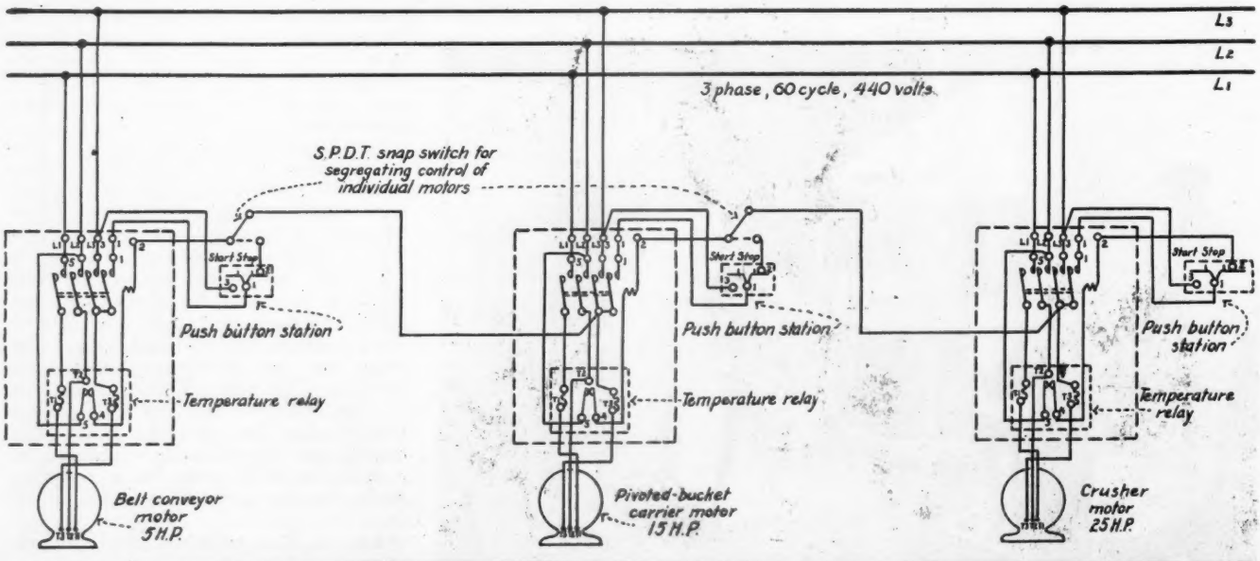
This emergency scheme maintained constant voltage on an alternator and prevented a plant shutdown.

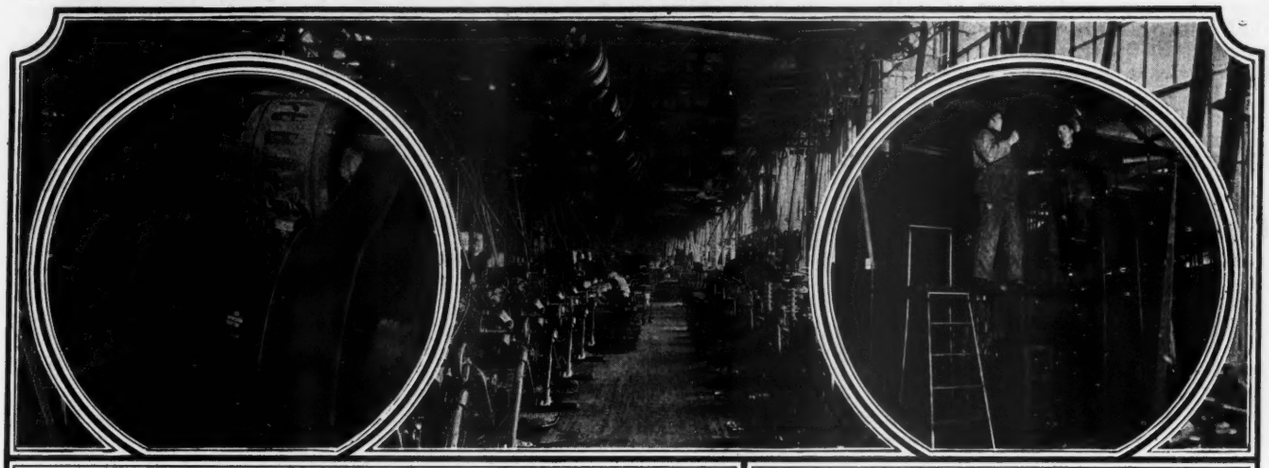
In the diagram *A* is a telegraph key; *B* the exciter field rheostat; *C* the exciter field; *D* the alternator field rheostat; *E* the alternator field and *F* the stator winding.

The telegraph key was mounted upon a table in front of the switchboard, so that the voltmeter could be watched, and one of the helpers was detailed to operate it. By this means the voltage was maintained constant during the working hours when the large machines, such as sizers and cut-off saws, etc., were running. At other times it was maintained nearly constant by changing the rheostat arm positions for various loads, such as lighting and wood planers which carried a steady load.

In this way several important orders were saved and the plant kept in operation until the arrival of the voltage regulator.

W. L. STEVENS.
Construction Engineer,
Smith Robinson Co.,
Vancouver, B. C.





Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

How Frozen Motor Bearing Was Removed and Repaired

ALONG about ten o'clock one morning our motor began to slow up and shortly stopped altogether. Fuse tests showed that we had power right up to the machine. When we tried pulling on the belts we discovered, however, that something was stuck. This was finally traced to one of the bearings on the 30-hp. Westinghouse induction motor, and we couldn't budge the thing. Investigation showed that the oil ring had jumped and landed on top where it stayed high and dry; it was a motor that was not yet equipped with oil ring retainers but this was the first time in five years that we had had any trouble.

A fine fix that was. A frozen bearing tied up the whole shop and there was no other machine shop within ten miles! We were about to dismiss the men for the day, for more than half of them were doing actual machining operations, when the foreman offered to retain six men to do the repair job and find hand work for the remainder of the machine hands.

Quickly dispatching three of the men to preliminary work, he took the other three to the job of getting the bearing free from the shaft. That proved to be more of a task than had been anticipated. The motor head was of cast iron, of light ribbed form, and would not stand much of a stress; that made it harder to put any pressure on it to help pry the bearing along the shaft, and the possibility of a complete tie-up if we lost the motor head made us more than careful. If the head were pulled off the bearing, leaving the latter stuck on the shaft, there was no way to get behind the bearing to press or drive it off.

In the end, we attached a piece of flat bar stock to the motor head by clamps and bolts. This gave us a lever 10 ft. long which we used to free the bearing from the shaft and, very slowly, we were able to free it enough to move it along and off. All the while we were afraid that the set screw let into the bearing from the head would shear off, but it didn't.

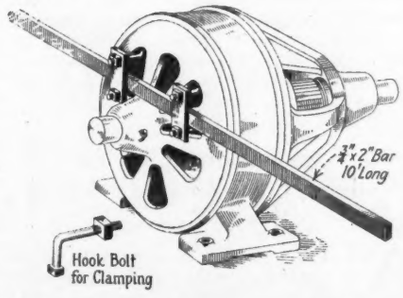
Meanwhile the men detailed to other parts of the job had a lathe ready to bore out the bearing, had a fire and the babbitt hot, and had prepared a mandrel and a set-up to re-babbitt the box. The old babbitt was melted out, and the new metal was soon solidifying in its place. One of the gang had already smoothed off the shaft and found it to be unhurt.

The best lathe hand was given the job of chucking the newly babbitted piece and boring it out. But how were we to bore it out when the only power in the place was gone?

The foreman had supplied the scheme, which was to use human power, and he had provided well for it. There were now five men from the job who were waiting around and these five were formed in line in front of the lathe, to pull the belt. This they did with a will. It became a sort of game and as fast as one man dropped his arms in sheer exhaustion, the next in line took his place and followed suit. Actually, this man-power was almost as speedy as electric drive would have been and the man who took the cuts found he had little time between them, the boys really making him hustle and taunting him with his lack of push.

In this way, the bearing was made ready for use. Oil grooves were cut and it was replaced in the head, after checking the fit by trying it first on the shaft. The motor was assembled and the machinery started again in a little less than five hours. The cost to us was about $25, but that was only a trifle of what it would have been but for the bright idea of the foreman.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.



The oil ring jumped out of place and the bearing froze.

A ¾-in. by 2-in. bar 10 ft. long was clamped to the end bell with hook bolts as shown. Two men carefully turned and pulled at the bar until they worked the head off and brought the frozen babbitt bearing along with it. More heroic methods might have broken the end bell. How the problem of boring out the bearing when no power was available, was solved, is given in the accompanying item.

Why Shafts Peen Under Inner Rings of Ball Bearings

IN THE case of belt-connected motors, there is sometimes a tendency toward a shaft-peening action under the inner rings of ball bearings. This is particularly noticeable when a belt is laced instead of being made endless with a cemented joint. The repeated shock on the driving pulley, which is transmitted to the bearing as the belt lacing strikes the pulley will, unless ball bearings are very carefully fitted, start this peening action under the bearings. The same action is started in a gear drive connection when one or two teeth are broken so that a similar shock occurs when these points of the gear engage and let loose.

A well known ball bearing manufacturer states that this trouble can be overcome by the use of a wide inner ring with a width equal to its bore. The advantage claimed for this greater width of inner ring is that the extra width affords the shaft proportionately greater support to resist vibration. At the same time the mounting is kept much more compact and the inner ring

does not require such a close fit on the shaft. In this way the danger of expanding the inner ring and cramping the bearing is avoided.

Getting More Power at the Die of Punch Presses

OCCASIONALLY a shop needs to get more work out of a punch press than it is designed to turn out. Usually manufacturers have put ample strength into the machines for their flywheel size and speed and this excess permits a certain amount of crowding to be resorted to on special jobs. Again, in case an executive is hard pressed he may be willing to take a chance on strength to get work out.

The commonest way to get more powerful strokes is to speed up the machine. A full knowledge of safe rim speeds for cast-iron wheels should precede such a change. As the available power is increased as the square of the speed, a slight change will often give the desired result. Large increases in speed are not always successful because the required increase in speed of hand feeding cannot always be made.

Increasing the weight of the rim is also a satisfactory method. A spare flywheel may be bolted to the side of the one on the press, or carried on an extension of the shaft. One shop had some steel railroad tires about 3 ft. in diameter and occasionally attached these by means of bracket castings to gain more "punch" for odd jobs. When this is done care must be exercised to keep the wheel balanced.

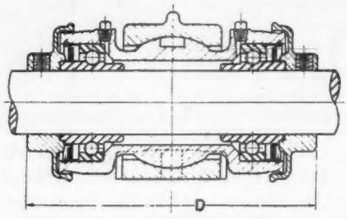
On punch presses and other similar machines with an adjustable stroke, it is a common expedient to increase the stroke for the purpose of decreasing the fraction T'/T which must be solved in the equation to determine the energy available. T' is the time in seconds of the actual cutting and T the time of the complete stroke. This works out well in some cases, but in one recently noted, it was tried to no avail. The men decided that the machine was too weak, when their reasoning was upset by the suggestion of the operator that they *shorten* the stroke and thus increase the ratio of the power arm to the work arm. It worked.

A plant that was cutting small shapes of leather from piles of soft hides an inch thick with cutting dies, resorted to a still different method of getting more power. The punch press had two notches in the flywheel hub to engage the bolt. The operator was a fast worker and could have "caught" every other stroke if the press had been running continuously, but continuous running would not have allowed time for shifting the work. He tripped so rapidly that the flywheel did not have time to recover its speed and, therefore, the machine often stuck. The remedy was to plug one of the notches in the hub. Then, with a white paint mark on the inside of the rim to indicate the position of the remaining notch, the operator could get the recovery of practically one whole revolution. His hourly output was increased above what it had been when the machine stuck from quick tripping.

An interesting "stunt" was done with a machine which had a "loaded" flywheel to increase its power to punch out pasteboard discs or wads. The legs were taken off and the press turned bottom side up; the legs were then attached on the side. This gave an unobstructed surface on top on which were placed the mailing tubes into which the wads were forced as cut. This was simpler than putting the tubes below, for then some sort of a follower would have been required in each tube to prevent crossed wads.

Dust Seal for Hanger Box and Pillow Blocks

UNDER conditions where there is an unusually large amount of dust, such as exist in cement mills, grinding rooms, mines or woodworking plants, it is almost impossible to exclude dirt from bearings. However, some industrial plants of this type are using a dust seal, as shown in the accompanying illustration, which can, if desired, be furnished with hanger boxes and single or double pillow blocks.



This shows the details of the dust seal on a hanger bearing.

The illustration, which shows the design of this seal, is practically self-explanatory. The extra seal is merely an extension on the self-locking collar which encloses the end of the box and fits over the corners so as to keep the dust from working down. The corners of the box are cut down and have a rim so that the seal closes down around them snugly. This rim stops any dirt that might otherwise get around. Since this seal revolves with the collar and shaft, it tends to throw the dirt out by centrifugal force and thus makes a dust-proof enclosure. This seal (Fafnir Bearing Company, New Britain, Conn.), is necessary only under exceptionally dirty conditions, since in most cases the pressed-steel dust caps are found sufficient.

Suggestions Which Reduce Cost When Ordering Bevel Gears

ANY article which is special or made to particular order must necessarily cost more than if standard products are used. This is especially true in many products used by industrial men. Frequently even special articles such as bevel gears have certain standard dimensions which most manufacturers of this equipment can supply.

Two of the most important items in the cost of small quantities of bevel gears are pattern and drafting-room expenses, together with the cost of entering the shop order with the necessary information for its proper execution. Each pair of gears requires a sketch or drawing showing outside diameters, face angles, edge angles, back angles, cutting angles, hub length and backing of each gear and pinion. Patterns also must usually be made unless standard listed gears are used.

Even if a manufacturer has several thousand well-assorted, bevel-gear blank patterns, it would be safe to say that in not more than one instance out of ten could existing equipment be used without alteration.

This may be better understood when we analyze the pattern situation more closely. Bevel gears mesh correctly in pairs only. Consider for example a 16-tooth pinion mating with a 48-tooth gear with ratio of 3 to 1. If the number of teeth in the pinion are increased or decreased, it will change the angles of the mating gear. As a matter of actual practice, if a pattern were made for the above pair of gears, it would probably be usable for the same number of teeth (48) of the same pitch and face to mesh with a pinion having one or possibly two teeth more or less than 16. However, a very careful check of the pattern would have to be made to determine this. From this it will be noted that to carry the necessary patterns for all combinations of bevel gears would be impossible.

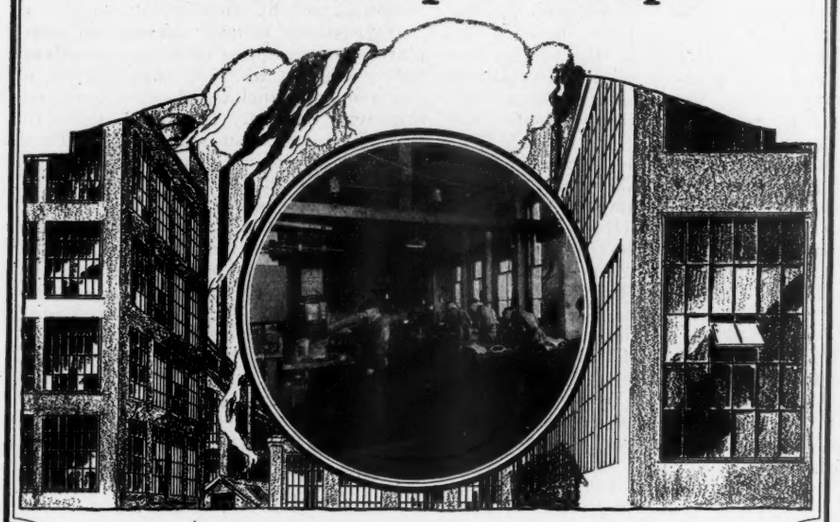
By selecting listed bevel gears practically all of this expense is eliminated. Patterns are made and are used frequently. Also, complete drawings are kept on file. The saving of time as well as expense in executing an order is still further increased. Although it may sometimes appear difficult to use standard sizes of bevel gears where a definite reduction must be made, most installations, however, can be made to use standard sizes and ratios. For example, in most installations, bevel gears form only part of the reduction in speed. In fact, it might even be said that they are usually the second or third reduction, the first frequently being made by means of pulleys or spur gears, both of which can be readily manufactured in any reasonable ratio.

For example: If a total reduction of 12½ to 1 must be had involving a bevel-gear drive, it will be found advisable to commence with a standard listed pair of bevel gears, say 2½ or 3 to 1 for the second reduction, and make the first reduction by means of spur gears or pulleys of the proper size to complete the total reduction ratio desired.

It is usually much more economical to use rather small ratios of bevel gears, making most of the reduction where possible by spur gears. Bevel gears are much more expensive than spur gears, even if standard listed sizes are used. A bevel gear is not only more expensive than a spur gear when the pitch diameter, face and pitch are equal, but also the bevel gear will only transmit about three-quarters of the horsepower of a corresponding size of spur gear. This increases the cost per horsepower still more and makes the cost of bevel gears approximately twice that of spur gears on a cost-per-horsepower basis.

WARREN G. JONES.
President and Gen. Mgr.,
W. A. Jones Foundry & Mach. Co.,
Chicago, Ill.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Loose Rotor Bars Cause Trouble With Electric Grinder

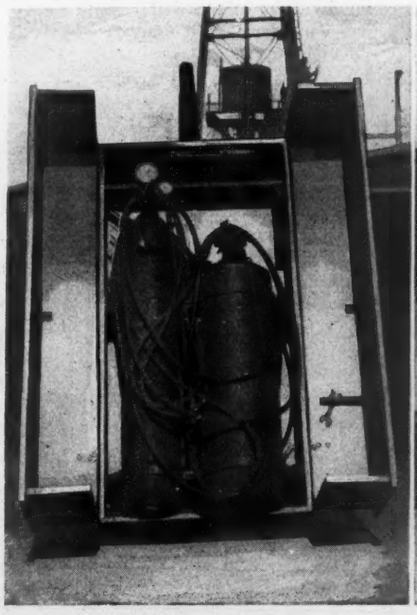
RECENTLY, a ¾-hp., 3,600-r.p.m. electric grinder which would not come up to speed was sent in for repairs. I checked up both windings and the switch, but could not locate the trouble. I then tried cutting out the starting switch and bringing the starting leads to the outside of the motor, thinking that perhaps the switch springs were too weak, but still the motor would not come up to speed. The rotor appeared to be in good condition but after resoldering the bars the motor came up to speed and has worked satisfactorily ever since. In this instance, the rotor bars seemed to be so sound and tight that resoldering was used as a last resort.

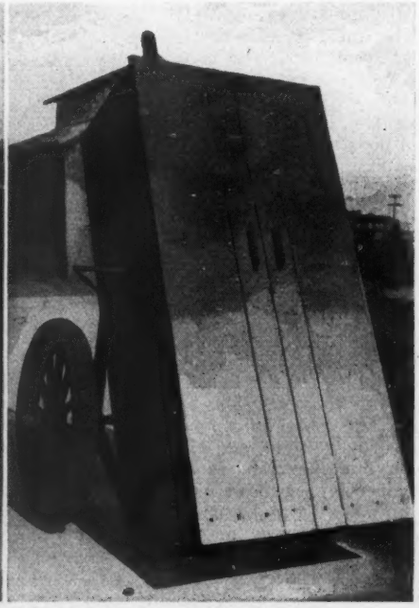
Albany, Ga. B. BELCHER.

Trailer for Making Welding Outfit Portable

EVERY industrial man knows how much the usefulness of repair equipment is increased by making it portable. Frequently, this is easily done. For example, with oxyacetylene welding outfits, most manufacturers will provide a special two-wheeled warehouse type of truck for transporting the containers of the oxygen and acetylene. However, when it is desirable to extend the field of operation some distance, such an outfit is too small for convenient yard work.

In one plant where it was desired to use a welding outfit over a considerable area, a special all-weather trailer was constructed as shown in the accompanying two illustrations, which were furnished through the courtesy of The Linde Air Products Co., New York City. This trailer, in addition, carries all the auxiliary tools or accessories required, including a considerable quantity of welding rods. The weight of the containers is so placed that the trailer practically stands on end in the proper position for welding when the tongue of the trailer is released. However, it may be easily coupled on to a truck for hauling some distance, or if the distance be short, one or two men can easily move it. When the doors are closed and the trailer is standing on end as shown in the illustration at the right, it can be left out in almost any weather.





With a trailer of this sort, the range of the welding outfit is increased to the distance which a truck can take it. Also, there is sufficient space for every accessory needed.

Savings Affected by Dipping and Baking Armatures

IN A discussion given before a recent meeting of the Association of Iron and Steel Electrical Engineers, M. R. Armstrong, of the Westinghouse Electric and Manufacturing Company, made the statement that dipping and baking armatures have returned handsome dividends in the form of decreased motor maintenance. The following interesting data were given in corroboration of this statement:

A large electric railway company on the Pacific Coast installed an electrically-heated baking oven. At the same time a systematic schedule of dipping and baking armatures and field coils was inaugurated. Of the 1,800 motors in use, 70 per cent have been in service approximately 25 years. Before dipping and baking was inaugurated, failures were running at the rate of about 70 per month. Two years later, after the majority of the motors had been dipped and baked, failures were reduced to about 24 per month. This was a reduction in failures of approximately 64 per cent. The superintendent of this shop estimated that the total cost of dipping and baking, including all labor in removing and replacing the armatures, was between $6 and $7 per motor. He felt this expense was amply justified, as the life of the armatures was extended at least five years and the interruptions of service due to armature failures were very greatly lessened.

A large New England company operating in several towns adopted systematic dipping and baking. In one shop servicing 475 railway motors, the monthly failures were reduced from 150 to 28. In another shop servicing 400 motors, the failures were reduced from 100 to 24.

Another company has made available the following data from records kept over a period of 13 years: Early in this 13-year period, systematic baking of their railway motors was inaugurated. Before dipping was start-

ed, the average service of a motor per failure was two years; after dipping and baking they obtained seven years' service per failure. Looking at this from a financial point of view and using their actual figures on cost and failures on the 300 motors involved, the figures show that their savings each year after paying all expenses of dipping and baking, amounted to $2,350.

All of the above examples are from railway service, but it is reasonable to assume that any method which will give such results under the conditions of railway service, will be correspondingly beneficial in industrial work.

Some of the Points to Think About When Repairing Storage Batteries

IN RENEWING storage batteries of stationary types, there are several details that must be given attention to prevent accidents which may be expensive, result in personal injury, or cause an interruption of service that may involve many dollars loss.

A careful check-up of the output of the battery which is to be renovated or repaired should be made before starting the job. Other questions that come up are: Can the battery in use be temporarily substituted? If so, are charging facilities available for charging the substitute battery that is to replace the original battery while undergoing repairs, changes, etc.? Is ample space provided for the temporary installation of the substitute battery? Are temporary battery leads accessible for use during the renovation? Can the substitute battery be operated by local attendants without involving any extraordinary precautions or complicated arrangements should an emergency arise regarding the charging and discharging of the temporary battery? All of these questions and possibly others that are involved in the changes or the kind of work that is to be done to the original battery should be given careful consideration to accomplish an efficient, careful and uneventful job.

The question of material, tools, facilities, and labor is usually neglected before starting the job and very often proves expensive in doing the job, in that the employer, contractor, jobber and possibly the workman suffer losses because preliminary details were not given the consideration that was due them. This not only applies to a battery job but to many other jobs where an interruption of service, or a delay is costly during repairs or changes.

The question of material and tools is, in my estimation, of the utmost importance, when efficiency must be considered. A list of supplies, material, and tools should be made up before starting the job. The workman who is to do the job should personally see that the proper items are shipped, and if a lead burning job is to be done and oxyacetylene or oxygen and hydrogen equipment is to be used for the burning, the operator or workman should check the equipment to see whether high- or low-pressure gas is to be used and that the proper burning tools are shipped. It has happened very often that the proper type of gas was not shipped to the job and the burning tools that were shipped could not be used because the connections on the tanks were different from those on the burning tools. This is due to the fact that a careful check of all material and tools had not been made. It is a well-known fact that high-pressure gas will not work successfully with low-pressure burning tools, and vice versa.

The question of other material and tools is likewise of importance. There is an old saying which is occasionally heard and sounds something like this: "A good workman or mechanic needs but few tools to do a job." This is true to some extent but an addition should be made to the saying and I suggest this: "Good and many tools and of the proper kind help the good workman or mechanic to work efficiently." Of course, mechanics are doing jobs without proper tools but compare these jobs with those done by the mechanic who has the proper tools, and I am sure that you will find a remarkable difference justifying the extra expense of purchasing the proper tools. Material in some cases is just as important if not more so than tools; inferior or less expensive material might show a saving on the books or contract, but will it prove to be more economical in the long run?

Protective clothing is also essential when working with electrolyte. These items should consist of rubber boots, rubber aprons, rubber gloves, and goggles of some description that will protect the eyes when either burning lead or pouring acid. Serious injury to the eyes may occur when least expected, especially when burning lead, as air pockets form and when there is an air pocket an explosion may occur, and invariably the eyes are injured. When pouring acid, splashing sometimes occurs and the eyes are usually injured. Protective material usually pays for itself in little or no time.

Parts of old batteries should be salvaged or sold for junk, which helps to lower the cost of repairs made on the battery. Sediment should never be thrown away or discarded. Junk dealers are always ready to purchase both the old electrolyte and sediment. After completing the job all tools that have been used should be washed in a solution of bicarbonate of soda, dried and oiled. This protects them against corrosion caused by chemical action.

Instructions usually accompany new plates when shipped from the manufacturer, stating whether they are in a charged or uncharged condition or otherwise treated. This also applies to new separators. Automatic water fillers used for replacing evaporation in the pilot cell of the battery usually have instructions regarding their installation. For the initial charge, instructions are also furnished regarding the number of hours the battery is to be charged, how to ascertain when the battery is said to be fully charged, etc., and unless otherwise specified these instructions should be closely followed.

Dallas, Tex. F. J. H. KRAUSE.

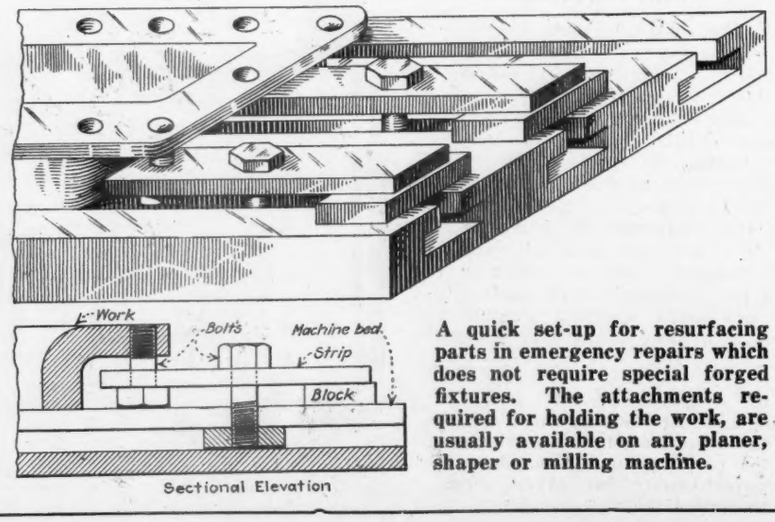
How to Make a Low Clamp for Refinishing Flat Surfaces

FREQUENTLY emergency repairs require resurfacing work on the shaper, planer or milling machine, which necessitates the use of some special form of clamp that will not protrude above the work. Many devices of this type are available to the machinist, but the repairman who is called upon in emergencies may not have them, as they generally consist of special forgings or machined parts.

The accompanying sketch shows a simple but serviceable holder, which can be made up of pieces available around almost any repair shop. This holder consists of a drilled strip, two bolts and a block for each of the clamps. These parts need not be of any particular shape or size and pieces on hand may be utilized.

In the majority of jobs the flanges are fitted with tapped holes. In some cases it may be possible to drill and tap holes. This fixture takes advantage of this condition as the work is held by screws in these tapped holes, as shown in the sketch. This simple clamp will save time and labor on any repair work to which it can be applied.

Washington, D. C. G. A. LUERS.



A quick set-up for resurfacing parts in emergency repairs which does not require special forged fixtures. The attachments required for holding the work, are usually available on any planer, shaper or milling machine.

Some Emergency Alterations to Small Commutators

THE following examples of making alterations to small commutators to meet emergency conditions are actual experiences that have happened in the repair shop where I am employed. and as I know that they will give satisfactory results they may be of interest to other readers of INDUSTRIAL ENGINEER.

It must be always remembered, however, that in making such changes we are getting away from the original data and as we have to assume that the original design was the best for the machine in question, we must realize that in making any departure from the original we are taking a chance and the altered machine cannot be 100 per cent efficient, even if no noticeable difference in operation is detected.

Anyone who has had experience in repair shop work knows that there are many times when it is either impossible to get the necessary parts immediately, or if they could be obtained the expense would be such that the customer would not understand why a small repair job should cost so much. Knowing these things, it is common practice to make things do or fix them in such a way that they will operate to the satisfaction of the customer, who is usually interested only in the fact that the machine runs and gives him service.

We always feel that it is all right to make changes and "gyp up the job" if we can feel certain that the operation of the machine will not be impaired, but there is nothing to be gained by "just getting away with it" for the time being. Rather than have a dissatisfied customer from giving him a patched-up job that will not hold up, we either make it as good as new or advise him of the condition of the machine and the expense necessary to do the work properly and be guided by his answer. Sometimes the customers would rather take a chance. In case any reader finds it necessary to make some of the changes mentioned below, they should be as certain as possible that the change is feasible.

Some time ago, we had an armature with twelve slots and twelve commutator bars; the coils were wound with 150 turns of No. 29 d.s.c. wire, span 1-and-6. The commutator had a bar that was grounded solid. As it was a pressed, barreled commutator we were unable to open it and repair it, but as we had a thirteen-section commutator in stock, we put this on the shaft and jumped two bars together with a short jumper behind the shoulder. This made two bars the same as one and gave us the same number of bars as we had before, with the exception that one bar was wide. At the time we tried this, we were afraid that there would be sparking at the brushes, but when the motor was assembled and run the results were entirely satisfactory and there was no noticeable difference from the action we would have had with the proper commutator.

Another case of making what you have on hand answer for the part that you cannot get immediately was when we had a twelve-slot armature with a twenty-four-section commutator. The commutator was in such shape that it was impossible to repair it and we could not pick up another one like it; so we rewound the armature with twice the number of turns per coil and half the number of coils and put on a twelve-section commutator. The original data was twelve slots, two coils per slot, seventy-five turns of No. 30 d.s.c. wire per coil. We rewound the armature with twelve coils of 150 turns per coil. There was slight sparking at the brushes as the result of this change, but not more than occurs in many motors that are wound according to the original design.

Another time in putting all new mica segments in the commutator of a 1/6-hp. armature, a bar was lost. Losing one of the bars was pure carelessness and the proper thing to do would have been to make a new one, but the job had been promised for that afternoon; so we cut four more mica segments and put them in on the quarter and cut one coil out when we connected the leads in the commutator. In this case, also, there was no noticeable difference in the operation of the machine.

The same expedient could also be used in case a bar were so badly burned that it was beyond the point where it could be turned down to true it, or where an open circuit had caused bad burning between bars of the commutator.

In one instance, a customer had allowed an armature with an open circuit in the winding to run for a long time. The result was that a deep groove had been burned between bars, eating away almost all of the mica and almost half of each bar deep down into the commutator. In this case, there was so little of the bar left at the top that we filed both bars down to a size where together they made up the width of one good bar. We then assembled the commutator and put in a couple more mica segments to make up the width of the missing bar and cut out the coil that had the open circuit in it.

Trouble with short-circuited commutator bars caused by carbonized spots in the mica segment is very common and the best thing to do is to put in a new segment. However, when the commutator is one of the pressed or crimped type that has the barrel and end rings riveted or crimped over, it is nearly impossible to open it up for repairs because of the difficulty encountered in getting it tight again. A great many of the small commutators are of this crimped type and whenever they come in with shorted bars from carbonized spots, we try to pick out the carbonized mica with a sharpened hack-saw blade.

Quite frequently, there are several small bad spots; we clean these out and plug the holes with Early's commutator compound. litharge and glycerin, or finely powdered mica dust and waterglass. If the hole goes deep down between the bars and cannot be cleared, we plug it, jump the two bars together and cut out a coil there. This is really better than leaving some of the burned mica in and using the commutator in this condition. because in time these shorted bars will cause the coil to burn out, while with the bars jumped together and a coil cut out there will be no noticeable difference in the operation.

Darby, Pa. GEORGE WM. HANLON.

Handy Method of Obtaining Proper Brush Spacing

IT OFTEN happens that the man who is investigating a reported case of trouble, is not equipped with tools or instruments to correct it, mainly due to his being misinformed as to the nature of the trouble or the type of apparatus to be worked on. Take the case of a d. c. motor or generator which is commutating poorly. Invariably the proper thing to do first is to check the brush spacing if there is any possibility of the spacing being incorrect.

The most accurate method of doing this spacing, and the method commonly used, is to place a piece of paper around the commutator and after marking where it laps, remove the paper and step it off with dividers or measure with a scale or rule a number of spaces equal to the number of brush studs.

After the paper has been divided off in this way, the writer may add that lines should then be drawn across the width of the paper at right angles to the length to check each brush-holder or box and not one holder only on each stud, as the insulating washers may be warped. In this case steps must be taken to make all holders line up parallel to the commutator segments.

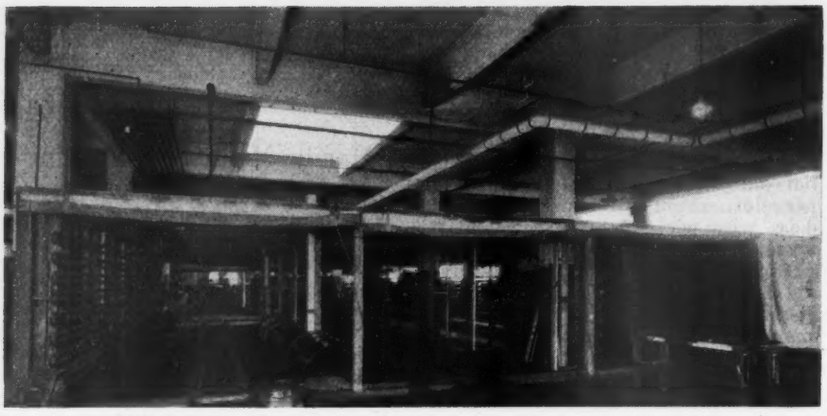
When dividers, a rule or square, are not available this method of spacing can still be used and if a little care is taken, an accurate job can be made as follows:

Take any piece of paper about 8 in. longer than is required to encircle the commutator and after marking it with a straight edge, cut off one side parallel to the length; then fold it back about 6 in. on the length, keeping the edges even and after creasing, cut the 6 in. off. A piece will now be had with two straight sides at right angles to each other and approximately 2 in. longer than the circumference of the commutator. If a straight-edge is not available a piece of newspaper will answer the purpose as this will have the two edges already cut at right angles to each other.

After placing this strip of paper on commutator with the straight side against the shoulder or risers, mark where it laps over. Then remove this strip of paper, fold it in half and crease carefully, keeping the edges even. A piece of paper will now be had which will give proper spacing for a 2-pole machine: namely, brushes 180 deg. apart. For a 4-pole machine or 90-deg. spacing, fold each 180-deg. piece in half and crease. A 60-deg. or 30-deg. spacing can be made in the same manner by folding the paper on the third or 120-deg. instead of on the half or 180 deg.

The above method will not only be found to be convenient, but it is both quick and accurate.

Repair Foreman, JOHN E. HOLTMAN.
Westinghouse Elec. & Mfg. Co.,
Denver, Colo.



This is one of three kilns constructed of gypsum wallboard, which have been in service six years.

The ceiling and walls of this kiln in a truck factory near Buffalo, N. Y., are built up of sheets of non-combustible gypsum and fiber on 2-in. by 4-in. studs and cover a floor area of 40 ft. by 60 ft. Wallboard is nailed directly to the studding with cement-coated nails and the joints are filled with a special finisher. In some cases wooden panel strips are used, as on the kiln shown at the beginning of this article, but if care is exercised in making the joint it is hardly noticeable and does not need to be covered up. This material can be used in kilns operated up to 200 deg. F. and 35 per cent humidity.

Uses of Wallboard in Plants

(Continued from page 237)

nailed directly to the studding and the joints filled with a special finisher. In some such kilns the joints have been covered with wooden panel-strips but this is not necessary. These kilns are operated at a temperature of 150 deg. F. to 170 deg. F. on a 24 hr. a day schedule with a low heat loss. In these kilns the wallboard is used on both inside and outside for double heat insulation.

Other than automobile plants also make good use of these kilns. For example, 11,000 sq. ft. of wallboard were used in the dry kiln of the Brook Candy Company, Chattanooga, Tenn., where it is under a constant temperature of 140 deg. F. This material is especially appropriate here, because it is absolutely non-odorous as well as free from crumbling. In some installations Sheetrock has been used in the construction of kilns in which a temperature up to 200 deg. F. is maintained, with 35 per cent humidity. This material is not recommended for use at a higher temperature or humidity.

Gypsum suffers little from gases that occur in many manufacturing processes. Any gases or fumes which affect the fiber covering or the fiber in the wallboard will affect it. Under most conditions ordinary paint will protect the fiber covering on the wallboard from the action of gases or fumes. There are special protective paints, that are not affected by acids or fumes. These may be used in cases of necessity.

Among other uses, which might be mentioned are: lining of lofts, fire protection for basement and other ceilings, as an insulator instead of wooden sheathing behind brick or masonry veneer or wooden siding, as a fire stop in partitions and floors and as a sound deadener between rough and finished floors.

In fireproof buildings it is also used for the construction, either on metal or wooden studs as supports, of walls, partitions and ceilings. Another common use is in the construction of fresh air ducts, ventilating shafts, enclosures for pipe lines, and so on. Its dual purpose as an insulating material, the fact that it does not warp and also the large sizes in which it can be obtained make it adaptable for mounting charts, maps, blueprints, shop bulletin boards, for the backs and bottoms of cases and drawers for filing blueprints and other light material and for many other applications which any ingenious plant man can easily find.

Wallboard was used in the construction of this storeroom.

Besides using gypsum wallboard to finish the walls and ceiling of this storeroom the same material was used in the construction of the sides of these stock bins. As this is a non-combustible material, the fire-resisting qualities are especially desirable in storeroom construction.

Winding Armatures by Machine

(Continued from page 234)

potential will be sure to break down the insulation of the unimpregnated part sooner or later.

The high dielectric strength of enameled wire helps greatly in preventing breakdowns. Wires which have enamel as one of their coverings are to be preferred, in small sizes, for this reason as well as for their heat-resisting qualities.

There are many good varnishes on the market, but owing to the fact that enamels are themselves applied to the wire as a liquid varnish, the insulating varnish used should be designed for use on enameled wire. Otherwise the varnish solvent may cut the enamel. For the same reason do not soak the armature too long in the varnish. It should be immersed just long enough for the varnish to penetrate the coils.

Do not use spirit or non-baking varnishes for impregnating. Shellac varnishes come under this head; their use for impregnating is practically discontinued.

Overhauling Electrical Instruments

(Continued from page 222)

the friction compensation has been adjusted with the potential circuit connected to the service side. (6) In the case of induction meters, short-circuits in the current coils. Of course, we have to deal with only the first-named cause, as vibration, improper connections, short-circuits and so on would be eliminated by our previous work and by the conditions under which the meters are tested. We overcome any tendency to creep by proper adjustment of the compensating or shunt coil.

Testing of induction, or alternating-current, meters conforms closely to the procedure outlined for direct-current meters, except that a high-grade indicating wattmeter is used to measure the power passed through the meter.

With polyphase meters each phase is tested and corrected separately. Then the current coils are connected in series and the potential coils in multiple across the line for a final check of the meter. One of the accompanying illustrations, Fig. 4, on page 222, shows our test bench. As will be noted, there is mounted at the back of this bench two testing boards from which any desired voltage, frequency or number of phases can be obtained for testing any kind of indicating or recording instrument. Several motor-generator sets supply power to this board.

The headpiece at the beginning of this article shows a general view of a portion of the *Meter Department*, with the test bench in the background.

After a meter has been tested and properly adjusted the cover is fastened in place and the meter either returned to the customer or sent to stock.

Overhauling and testing of voltmeters, ammeters, power factor meters and so on is carried out in substantially the same manner as outlined for watt-hour meters. These instruments likewise come to us exhibiting all of the different kinds of damage that may be caused by abuse or carelessness in handling, neglect, accidents, and natural wear and tear. Thus, the coils may be burned out or short-circuited, the instrument may have been dropped, with consequent breakage of pivots or jewels or damage to other parts. Again, the torsion springs in voltmeters and ammeters seem to become brittle with age and eventually break, thus putting the instrument out of commission.

When such instruments are purchased or sent in for repair they are thoroughly cleaned, if necessary, and then carefully inspected to determine what repairs are needed. New coils or new springs are put in, as may be required, flattened pivots are ground and polished and any other needed repairs are made. If the cases are bent or badly scratched they are straightened and refinished. The instruments are then checked against our standards and after any necessary adjustments have been made they are assembled in their cases and either returned to the customer or sent to stock.

Trade Literature *You Should Know About*

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Ball Bearings—A booklet entitled, "The Super-Strom," is devoted to a discussion of the design, material, workmanship, load-carrying capacity and dimensions of the "Super-Strom" ball-bearing designed for heavy duty. —Strom Ball Bearing Mfg. Co., 4593 Palmer St., Chicago, Ill.

Insulation Lacquer—A broadside entitled, "Why Dolph's Is Different." describes Dolph's air-drying electric lacquer and black baking Chinalak for the protection of electric motor windings.—John C. Dolph, 168 Emmett St., Newark, N. J.

Portable Electric Hoist—Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, Ill.—Bulletin 76-E describes and illustrates the Sullivan electric portable hoist made in single-drum and double-drum types, which is capable of lifting a vertical load of 2,000 lb. at the rate of 107 ft. per min.

Materials-Handling Equipment — Revolvator Company, 336-352 Grand Ave., Jersey City, N. J.—Bulletin 71 describes the Revolvator hand-operated lift-truck. Bulletin 75 describes the motor-driven, portable elevator. Bulletin 72 describes the line of barrel racks for use in connection with a portable elevator.

Oil Circuit Breakers—General Electric Co., Schenectady, N. Y.—Bulletin 47495.1, of 32 pages, is well illustrated by photographs, tables and diagrams and contains other details covering the construction, operation, price and characteristics of four new types of oil circuit breakers for controlling and protecting circuits of large capacity.

Ratchet Diestock—The Borden Co., Warren, Ohio—A folder describes the No. 3 Beaver Jr. ratchet diestock for threading 1-in. pipe and all smaller sizes in corners or other close places.

Stationary Dead-Front Switchboards—General Electric Co., Schenectady, N. Y.—Bulletin 67111-Class 15, describes this equipment with brush contact lever switches for 125 and 250 volts alternating or direct current and 500 volts alternating current from 30 to 600 amp.

Automatic Remote Control Starter—Bulletin 219 describes and shows diagrams of the construction and operation of a new automatic remote control starter for alternating current, squirrel-cage motors. These are made in two- and three-phase designs for 25, 40, 50 and 60 cycle at 220, 440 and 550 volts.—Crocker-Wheeler Co., Ampere, N. J.

Industrial Roller Bearings—American Roller Bearing Co., Pittsburgh, Pa. —Catalog 1006 carries a number of installation sketches, load capacity tables and photographs of roller-bearing-equipped machinery in a wide line of industries. These are essentially industrial bearings and are made in standard and heavy-duty types. Applications vary from heavy-duty presses to open-hearth charging cars.

Theft-Proof Lamp Sockets—A folder describes the construction and method of applying the Ren-lock to brass, porcelain or weather-proof sockets. With this lock it is impossible to remove the lamp without breaking the bulb, for which a special bag is provided.—Ren Manufacturing Co., 550 Main St., Winchester, Mass.

Portable Spray Painting Equipment—The DeVilbiss Mfg. Co., Toledo, Ohio —A circular describes the DeVilbiss portable spray painting system for spray painting houses, factories, building interiors and exteriors, railway equipment, bridges, ships and all kinds of large or stationary work. This includes a description of the various types of outfits and other equipment, together with their operation.

Switch Houses—Condit Electrical Mfg. Co., South Boston, Mass.—Bulletin 458 describes switch houses for indoor and outdoor service to afford protection for switching equipment where the power used does not justify the erection of a more expensive substation.

Portable Woodworking Machines—J. D. Wallace & Co., 134 South California Ave., Chicago, Ill.—A broadside consists of a number of illustrations showing some of the wide applica-

tions of Wallace portable machines in woodworking plants. These machines consist of portable jointers, planers, lathes, band saws, plain and universal saws, solder and glue pots. These machines are taken to the job or given to individual workmen to use at their bench or for maintenance work.

Interlock on Switches—Chas. Cory & Sons, Inc., 183-7 Varick St., New York City—Bulletin 105-29-B is on the new Cory-Robinson Interlock, which is designed to prevent accidental opening of disconnecting switches while under load by station personnel and to prevent damage from the same cause through malicious tampering.

Electrically Driven Tools—James Clark, Jr., Electric Co., Louisville, Ky.—Catalog 29 describes the Clark line of electrically-driven portable drills and their various attachments, center grinders for lathe heads, toolmaker's grinders, hand, bench and pedestal grinders and buffers, as well as other tools.

Electric Fans—Wagner Electric Corp., St. Louis, Mo.—Bulletin 143 entitled, "Wagner Fans," describes the various types of oscillating and non-oscillating desk, wall and ceiling fans for alternating and direct current, manufactured by this company.

Portable Electric Tools and Shop Equipment—The Black & Decker Mfg. Co., Towson, Md.—Catalog 8, under the above title, is a complete catalog, illustrated, of the portable electric drills, grinders, valve grinders, screwdrivers, socket wrenches, post and bench drill stands, and electric bench and pedestal grinders manufactured by this company.

Circuit Breakers—Roller-Smith Co., 229 Broadway, New York City—Bulletin 530 describes in 24 pages the technical details of the construction and operation and lists the various standard types of this equipment for use on direct and alternating current circuits of 6,600 volts.

Permeater and Core Loss Apparatus—Leeds and Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.—Bulletin 533 describes the "Burrows Permeater" for testing bar samples of steel for normal induction, residual induction and coercive force data, and also the "Epstein Core Loss Apparatus" which is used to test electric sheet steel for determining probable core loss through hysteresis and eddy currents.

Hand Elevating-Platform Truck—Sturdi-Truck Mfg. Co., Inc., 511 Orange St., Wilmington, Del.—A folder describes the Sturdi-Truck material handling service. Circulars show the construction and operation of this hand-lift truck, which has a step-by-step lift of 3 or 5 in., according to the model.

Steel Belt Fasteners—The Bristol Co., Waterbury, Conn.—A folder illustrates the application of the Bristol steel belt lacing and belt fastener for making belt repairs in industrial plants. This lacing is of the staggered staple type, and is applied with a hammer.

Pressure Type Water Filters—Graver Corp., East Chicago, Ind.—Bulletin 501, with the above title, describes filtration methods and shows the construction of the Graver filters which are furnished with a perforated strainer plate, instead of a pipe manifold and strainer head for the collection of filtered water.

Pressed-Steel Truck Platforms—The Youngstown Pressed Steel Co., Warren, Ohio—An 8-page catalog describes and illustrates the Youngstown corrugated, pressed-steel platform for hand- and power-elevating trucks, as well as the solid and sectional boxes, stake platforms and other equipment which are made to be used in connection with the platforms. Pressed-steel tote pans and compound boxes are also described.

Electric Equipment for Cranes—General Electric Co., Schenectady, N. Y.—Bulletin 48732 entitled, "Electric Equipment for Cranes," is an attractive 35-page bulletin well illustrated with photographs, diagrams, tables and charts. This bulletin has particular reference to crane motors and control, brakes, limit switches and other crane protective and operative features.

Direct Fired Unit Heater—American Blower Co., Detroit, Mich.—A folder describes the American Blower direct-fired unit heater for use in industrial plants.

Hammers With Renewable Head—The Bilton Machine Tool Co., Bridgeport, Conn.—A folder describes the New-Tip hammer which consists of a head in which new tips may be inserted by simply removing a screw and retightening it. Tips are supplied in lead, copper, fiber, or rubber in five sizes, weighing from ½ lb. to 6 lb.

Electric Fans—The Robbins & Myers Co., Springfield, Ohio—Catalog 1243 describes the R & M electric fans for alternating or direct current circuits in oscillating, non-oscillating, ceiling and ventilating fan types.

Materials-Handling Equipment — Barrett-Cravens Co., 1328 West Monroe St., Chicago, Ill.—A group of small bulletins describes the various types of hand-lift trucks and other materials-handling equipment manufactured by this company.

Adjustable Lamp Supports—Columbia Electric Co., 1109 Pine St., St. Louis, Mo.—A circular describes the universal bracket which is designed to give an extensionable and adjustable arm for lamps and reflectors. These brackets are designed to fit a variety of machines in industrial plants.

Material-Handling Equipment for Foundries—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.—Bulletin 61 describes the Shepard Electric Cupola Charger, and other electric hoisting and load moving equipment for foundries. The cupola charger is made in three sizes of 4,000, 6,000 and 10,000 lb. capacity in either the floor-operated or cage-operated types.

Automatic Time Switches—Albert and J. M. Anderson Mfg. Co., 289-305 A St., Boston, Mass.—Bulletin 37 describes the Anderson equipment for controlling electric circuits in which the element of time enters as the important factor such as on electric signs, automatic substations, time switches for two-meter service, switches for turning on and off night lights, battery charging, motor control and other purposes.

Ball-Bearing Motors, Buffers and Grinders—U. S. Electrical Mfg. Co., 200 E. Slauson Ave., Los Angeles, Calif.—A folder describes the U. S. electric grinders, buffers and polishers, as well as horizontal and vertical motors, all of which are provided with ball bearings.

Single Conductor Potheads—Price list 50 covers the complete line of single-conductor potheads with cap nut terminals mounted directly on the porcelain tube.—G. & W. Electric Specialty Co., Inc., 7440-52 S. Chicago Ave., Chicago, Ill.

Electric Fans—Century Electric Co., 1827 Pine St., St. Louis, Mo.—Bulletin 37 describes the Century alternating and direct current, oscillating and non-oscillating portable and ceiling fans.

Details of a Fuse Color Scheme

(Continued from page 229)

yellow, paint two red rings around them, and put sufficient fuse links in parallel to give us 150-amp. rating. The yellow case would indicate a 45-amp. fuse; one red ring around it would indicate a 100-amp. fuse, and the two rings would bring it up to 150 amp. Thus it can be seen that the red *rings* indicate variations in size above the rating for that color, just as the red *stripes* indicate variations in size below the rating for that color, as given in the accompanying table.

The practice of overloading a fuse cartridge is not to be recommended, however, and should be done only in case of an emergency, for temporary use.

Sometimes, also, it is desirable to put in solid fuses, as in the case of the neutral of a 220-110-volt lighting circuit and in this case we paint the whole cartridge red.

In case a maintenance man goes out on a call with fuses of the wrong rating, but the right size cartridges, he wraps a piece of tape around each cartridge to indicate emergency use, and replaces them with the proper fuses as soon as possible.

I installed this system in the plant of the Peerless Motor Car Co. at Cleveland, Ohio, and am at present installing the system in the entire plant of the Willard Storage Battery Company.

In both plants, the system is proving that our diagnosis of our troubles and the remedy decided upon were correct, and very satisfactory results are being obtained from the use of this method of marking and handling fuses.